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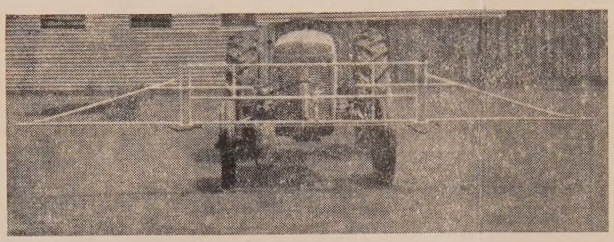

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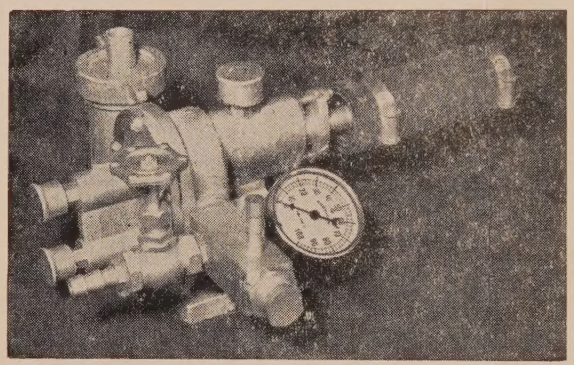

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POWER TAKE-OFF PUMP

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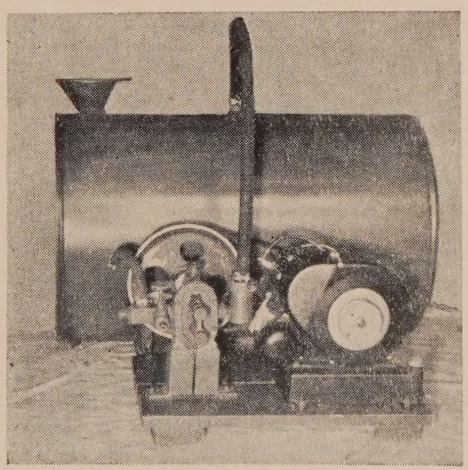

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The Journal of THE AUSTRALIAN INSTITUTE OF AGRICULTURAL SCIENCE

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MARCH, 1954

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Developing the Journal

The Publications Committee is continually trying to improve the scope and interest of the Journal, and the objective is to include, in every issue, some material which is the direct concern of each reader.

One of the main difficulties to be faced is the wide range of specialist occupations which must be covered. However, this can be met either by publishing a limited number of articles of a general type, or by including a large number of short notes on specialist topics in each Journal.

In recent years, Journals have included a proportion of general "Review" type articles and also a certain amount of information such as "News Items", "Institute Affairs", "Personal Notes" and "Branch Notes". The Publications Committee has had evidence of the popularity of these sections. However, as a further means of widening the scope of the Journal, it is considered that the "Technical Notes" section should be developed and expanded.

The idea behind the "Technical Notes" section is that it should include *short*, interesting pieces of information such as discussions of interim results of experiments or of observations noted as a sideline to main experiments, also theories could be advanced with some supporting evidence. The notes should be written as concisely as possible, and generally speaking, should range in length from 150 to 1,200 words, that is, between $\frac{1}{4}$ and 2 pages of the Journal. Emphasis will be placed on simplicity and clarity of presentation and expression. In view of their brief nature prompt publication should usually be possible.

These technical notes are not intended to replace good technical articles but to supplement them. This type of note would familiarise research workers with the work of others before complete publication of results is possible and, in this way, it would allow the author to stake a claim in a particular field and thus prevent overlapping of work. It is felt that a healthy column of this nature would cover a lot of ground and be of interest to workers in a large number of fields, moreover, it would provide a service to readers and permit publication of information which would otherwise remain on official files.

ARTICLES

SOME DEVELOPMENTS IN THE FREEZING OF FRUITS AND VEGETABLES IN AUSTRALIA

By S. M. SYKES

Since the beginning of World War II there have been some important changes in our methods of preserving and marketing food, and at the same time, there has been a change in the attitude of consumers to processed foods. Periodical shortages of some fresh fruits and vegetables have induced the public to turn to the use of alternative foods in preserved form and consequently the food preserving industries have expanded both in size and in the variety of products available.

Of the new developments, one of the most interesting has been the commercial application of quick freezing methods to fruits and vegetables, and, in this article, recent progress in the quick freezing industry of Australia will be reviewed and the main factors which are likely to influence future development will be discussed. However, before studying the Australian industry more closely, it is necessary for the reader to have some understanding of the commercial procedures normally used and of the progress that has been made in the U.S.A. and other countries.

Commercial Methods

PREPARATION

For vegetables, the methods of preparation are similar to those used in canning. Peas, for example, are harvested mechanically and passed through a viner —a special type of threshing machine which removes peas from the pods and vines. The shelled peas are then transported as quickly as possible to the processing plant where they pass through the various stages of preparation and freezing. They are, first of all, cleaned and washed and, in some cases, graded into sizes. After a short blanch or scald in hot water or steam they are cooled and passed over an inspection belt. The separation of peas of different maturity is sometimes performed by inserting a brine density type of separator between the blancher and inspection belt. After inspection, they are either taken directly to the freezing unit as loose unpackaged peas or they may be packaged in small cartons and then quick-frozen.

Other vegetables are given essentially the same treatment prior to freezing although the processing lines are, in general, less complex and require more hand labour than peas.

The preparation of fruits for freezing is relatively simple. Berry fruits are washed, sorted and, in some cases, sliced. They may then be either mixed with a proportion of sugar and filled into containers or, alternatively, covered with a heavy syrup after packing. Peaches are peeled, halved, pitted and sliced and covered with a syrup containing a preservative, e.g., sulphur dioxide or ascorbic acid. The methods for other fruits are very similar to those outlined above.

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Fruit which is packed as small lots of about one pound weight is usually quick-frozen and sold through retail stores to the domestic consumer. A much greater amount of fruit is packed in larger containers, e.g., 10 pound, 30 pound or 4 gallon cans, for the institutional market which includes hotels, hospitals, restaurants, pastrycooks, and the manufacturers of jams, preserves, cordials, etc. Institutional packs, because of their size, cannot be truly *quick*-frozen, and are usually placed in rooms or tunnels and *slow*-frozen.

FREEZING

There is no satisfactory definition which clearly separates modern "quick" freezing from the long-established methods of "slow" freezing. It is perhaps easier to consider what differences exist in actual practice.

"Slow" freezing (or "sharp" freezing) implies that the food is frozen, usually in bulk, in rooms or tunnels which are held at a temperature of about 0°F. or lower. Fans may be used to agitate the air and thereby increase the rate of freezing. The freezing time is at least 12 hours and often extends over several days. Included under the heading of slow freezing are the methods used for the freezing of sides of beef, boxes of poultry, rabbits and fish, and cans of egg pulp.

With "quick" freezing, on the other hand, the food is frozen in small lots, in special quick freezing units which are designed to freeze the food in a period which might range from a few minutes to approximately five hours. Descriptions of the different quick freezing units cannot be given here, but, in general, they fall into three classes:—

(a) Air blast freezers, in which a rapidly moving stream of cold air is blown over or through the product.

(b) Contact freezers, where heat is removed by placing the packages of food in direct contact with refrigerated coils or plates.

(c) Immersion freezers in which the food is passed through a bath of liquid which is maintained at a low temperature.

STORAGE AND DISTRIBUTION

One of the biggest problems in the frozen food industry is the handling of the product from the time it leaves the plant until it reaches the consumer. The food must, at all times, be kept frozen and, preferably, at or near a temperature of 0°F.

After freezing, it may be held in a low-temperature room at the plant and then transported in refrigerated vehicles to central cold stores, from where it is distributed either directly to the consumer or to the retail stores. The stores must be equipped with refrigerated display cabinets capable of holding the food at 0°F.

Most frozen foods will keep at a temperature of 0°F. for periods of up to one year and, in some cases, longer. A short time (up to about three days) at higher temperatures (e.g., up to + 15°F.) will not have an adverse effect on most foods, provided that they are promptly cooled down to 0°F. for the remainder of their storage life, and, of course, provided that they are not allowed to thaw.

Progress Overseas

U.S.A.

The quick freezing industry began in 1925, when Clarence Birdseye first produced and marketed quick-frozen packaged fish on a semi-commercial scale. The success of this first trial led to the application of the same methods to fruits and vegetables in the early thirties. Fruit packed in large containers had been frozen or, as it was then termed, "cold packed" for many years but the use of quick freezing methods introduced the new retail package to the domestic market. However, even though there is, to-day, an increasing proportion of frozen fruit going into the retail pack the greater part is still marketed in large containers for use by hotels and institutions.

Vegetables were not commercially frozen before 1930 but, between 1932 and 1952, the production rose to 896 million pounds (Anon., 1953). At present, the output of frozen vegetables, which is mainly for the retail market, is greater than that of fruit, which has remained steady for the past few years. A serious drop in production occurred in 1947 but this was largely due to a lowering of quality in meeting the big war-time demand for frozen foods. With processors well aware of the need for high quality, the industry has continued to expand since 1948.

The prominence of frozen fruit juice concentrates in the last five years has had a stimulating effect on other branches of the frozen food industry. In 1947 frozen concentrated orange juice was a little-known item in American food stores, but, to-day, it is the most widely used of all frozen fruit products, the total output for 1946-47 being over 47 million gallons (Anon., 1953). The success of this new method of marketing citrus products has resulted in a general improvement in handling and merchandising of frozen foods.

OTHER COUNTRIES

Quick freezing developments have occurred in other countries but on a much more limited scale. This is, of course, largely due to different conditions of general prosperity and different traditions of food handling and consumption. However, it is important to note that expansion is occurring and that the industry is following a somewhat similar pattern to that of the U.S.A. in its earliest stages. The United Kingdom, South Africa and several European countries are now producing for local and export trade.

Production in the U.K. has shown a definite increase in the last five years, but quick freezing is still small relative to other methods of food processing (Anon., 1949 and 1951).

There has been a gradual increase in the number of plants in most of the countries of Western Europe; however, the distribution and selling of frozen foods to the public has not apparently developed to the point where the plants can be used to their full capacity. In 1950, E. W. Williams (1950), Editor of the American trade journal "Quick Frozen Foods", reported that the industry in Europe could be compared with the American industry in 1937.

Australian Developments

It was not until 1945 that the freezing of fruits and vegetables began in Australia. A Sydney company, previously engaged in other forms of food processing, erected a quick-freezing unit and commenced producing for services and civilian requirements. Most of the pack was of the institutional type, i.e., in units of five pounds or more, although a small quantity was marketed in small cartons through a few retail stores. About this time appreciable amounts of frozen vegetables were sent to supplement the rations of Commonwealth occupation forces in Japan.

Probably the most significant step in the direction of establishing a retail market for frozen foods was the setting up of a plant in southern N.S.W. in 1948. This plant packed vegetables and fruit mainly for the domestic market. The organisation of a system of distribution through retail grocery stores required the construction of suitable refrigerated transport vehicles and low-temperature holding cabinets. In addition it was necessary to provide trained staff for the educational work involved in introducing a new type of food product to the retailer and consumer.

Most of the frozen vegetables produced in Australia have been for local consumption although, in recent years, there have also been some exports to overcome shortages which have occurred in certain lines overseas. Peas have been by far the most popular vegetable, and beans, cauliflower, broccoli, sweet corn and Brussels sprouts, have constituted most of the remainder of the total pack.

Apart from a small retail pack of peaches, berry fruits and cherries, fruits have been frozen mainly as catering and processors' packs of 30 to 50 pounds. These have been prepared by small companies or in conjunction with larger canning operations. Much of the fruit has been exported, although there are now appreciable amounts frozen for later conversion to fruit products such as jams, preserves, cordials, and the like. The most popular fruits for this type of pack have been pineapples, passionfruit, berry fruits, peaches and apricots.

Since 1950, further companies—usually those already engaged in other forms of food processing—have entered the frozen food field. There are, at present, six plants freezing vegetables and about eight packing some type of frozen fruit. Accurate figures on the production of frozen fruits and vegetables in Australia are not available at this early stage but a rough estimate would be about 3½ million pounds per annum, the greater part of this amount being vegetables.

Some expansion in the use of frozen pre-cooked meals has occurred. These fully-prepared foods are of special value to the caterers of air lines and shipping companies, and, to a limited extent, to householders. The first plant to operate in this field was installed in 1947 by the Sydney branch of an overseas air line. A larger factory was later built at St. Mary's, N.S.W., and the output of this plant is used entirely on planes and at airports. Small quantities of pre-cooked foods are being marketed through retail channels in the Sydney area.

Agricultural Implications

VEGETABLES

The establishment of large-scale vegetable growing for canning and dehydration during World War II has, to a large extent, paved the way for the growing of vegetables for quick freezing. The methods of planting, cultivation and harvesting are similar for all methods of processing, the main emphasis being on mechanisation and the need for carrying out these operations with a minimum of hand labour.

The selection of suitable areas for supplies of raw material is one of the main factors in determining the success of any quick freezing venture. The location of the processing plant in the heart of a good district, which produces a wide range of horticultural crops, has usually been the practice in other countries. There are cases where a plant draws its supplies from a central market but this type of operation is definitely the exception to the rule. Existing areas of large-scale vegetable growing are not plentiful in Australia and are often fully occupied with supplying the fresh market and established canneries. Some areas could be more fully developed to supply the requirements of a quick freezing plant which might be annexed to an existing cannery. The biggest expansion will, however, probably come from the conversion of areas now used for less intensive forms of agriculture and grazing to more intensive crops such as vegetables and fruit. The reliability of climate and the possibility of supplementary irrigation will be important factors in deciding whether a district is likely to be safe. The type of grower in a new district may also have an influence on the success of the venture. Interest and experience in vegetable growing on the part of the farmer can do much to foster the establishment of a new processing industry, and both growers and processors must realise that the future of a scheme depends on how well they cooperate in the early stages of development.

The growing of high quality raw material will mean that special varieties, suitable for freezing, will need to be selected for each particular growing area. Some progress has already been made in the adoption of suitable varieties of peas for freezing.

Peas for freezing should possess a uniform bright green colour and should retain good flavour and sweetness after

freezing. In the early days of the industry overseas, market-garden types were used but these had the disadvantage of uneven maturity of the pods. Machine cutting of such varieties gave a lower yield and a more variable maturity than that of canning varieties. The latter had been developed for mechanical harvesting and uniform maturity but did not possess the desirable quality of the market-garden types. New varieties were therefore bred and selected to combine the desirable characteristics of both the market-garden and canning types. Several of these are now in use overseas and some are already being grown in Australia.

Stringless beans which have proved satisfactory for freezing in other countries have been introduced to Australia. Some of these have gradually come into commercial use while others have not been accepted because of unsuitability to Australian growing conditions.

There are many varieties of the different vegetables which have the necessary quality for freezing but their ultimate commercial use will depend on their suitability to the soil and climate for each particular locality.

FRUITS

The success of frozen berry fruits in the U.S.A. and England suggests that the greatest expansion in the freezing of fruits in Australia will be in the form of frozen berry fruits. Small quantities of raspberries, loganberries and strawberries have been frozen in Tasmania and there has been some bulk packing of frozen strawberries in Queensland. Much of the berry production which is at present heat-processed for later use in jams, preserves and the like, could be frozen to give a better quality in the final article. It should be possible to establish a good market for frozen berry fruits to be used as a dessert fruit. Very little has yet been done to build up an institutitional market with hotels, restaurants and shipping companies or a retail market for small packs of 12 ounces or less.

Certain tropical fruits such as pineapples, passionfruit and mangoes are well suited to freezing. There should not be any serious difficulty in building up an assured market for bulk packs of these fruits, frozen individually or as tropical fruit salad. Packing in smaller containers might be profitable when other frozen fruits become more common in retail stores.

While frozen freestone peaches are unlikely to become an important item in the near future there could be some expansion. Apricots have not been frozen in large amounts in other countries in recent years and, in Australia, with adequate supplies of canned and dried fruit available, there would be some difficulty in building up any extensive market for a dessert pack.

Many of the commercial varieties of Australian fruits are suitable for freezing. However, any special emphasis on this method of preservation might mean that closer attention would have to be given to planting varieties which are more satisfactory than existing ones.

Storage and Handling

The expansion of quick freezing is always likely to be limited by the facilities for low temperature transport, bulk storage and retail marketing. Rail cars refrigerated with ice and salt are now in use in N.S.W. and cars of this type could cope with much of the bulk transport from factories to central stores. Mechanically refrigerated trailers which are now in use for the road transport of meat from country abattoirs could be modified where necessary. Delivery runs to shops will require well insulated trucks preferably fitted with eutectic plates or some other means of cooling.

Low temperature space in cool stores may have to be increased but already there is an awareness on the part of the cold storage operators of the need for increased low-temperature capacity in any new stores being erected. Retail display cabinets capable of holding food at 0°F. must be produced in large numbers. Even

in the U.S.A., where the industry is so much bigger the number of cabinets in stores throughout the country is still regarded as insufficient and is actually one of the major factors limiting expansion.

Other Factors Influencing Delevopment in Australia

In predicting future trends in Australia, there are certain basic points about food supply and consumption which must be considered.

1. Australia has a climate where fresh fruits and vegetables are available throughout most of the year. In other countries, where frozen fruits and vegetables are more widely used, there is a longer winter period when fresh supplies are unavailable. However, periodical shortages of fruits and vegetables do occur frequently in Australia, and it is to fill in these gaps that the frozen article can be used to greatest advantage.

2. The concentration of population in large cities in Australia, while in itself undesirable, does offer certain advantages in the marketing of frozen foods. The capital outlay on distribution facilities is proportionately less when retail stores are not widely scattered.

3. The capital investment required to start a freezing venture is heavy compared with many other forms of food processing. Apart from the usual preparation and processing equipment, refrigeration plant and low-temperature storage rooms must be provided and the financing of cabinets in retail stores is also a costly burden which may have to be borne by the company.

4. The need for high quality in frozen foods has been stressed earlier in this article. Experience in other countries has shown that any lowering of quality standards has a serious effect on sales. Not only must the raw material be of a high standard but quality must be maintained throughout all processing operations. Much of the work of preparation both in the field and in the factory requires hand labour which adds appreciably to costs, and it is most likely that mechanical improvements will be effected in the future whereby such costs are reduced. Packaging affords a good example of an operation where there is still much scope for the use of mechanical equipment. It is to be expected then that the prices of frozen foods will continue to be higher than those of other processed foods for some time.

While the main obstacles to expansion in Australia are economic a considerable amount of research is still necessary to improve efficiency in the growing of crops for freezing and in the various phases of production and marketing.

References

Anon. (1949)—U.K. Production Figures. *Quick Freezing*, **2**: 10.

Anon. (1951)—U.K. Production Figures. *Quick Freezing*, **4**: 11.

Anon. (1953)—Western Canner and Packer—Statistical Review and Yearbook Number **45**: 6.

Williams, E. W. (1950)—*Quick Frozen Foods*, **13**: 4.

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THE SCIENTIFIC AND SOCIAL PHILOSOPHY OF THE PEDOLOGIST

By C. G. STEPHENS

Permanent tenure of the land, confined grazing of animals, and systematic cultivation of the soil are among the many characteristics which distinguish civilised man from his nomadic ancestors and from present-day primitive peoples. This stationary system of land-utilization, assisted by various mechanical contrivances and chemical products, enables the modern farmer to produce food and other primary necessities far beyond his own needs. This surplus is distributed by various means to other people, including those engaged in secondary and tertiary industries. Despite this achievement the ever-increasing population of the world places a corresponding strain on our potential food production.

To-day, the soil, whose fertility is the ultimate basis of the welfare of all people, is one of the most critically placed of the world's resources. As a natural body it has an obvious intrinsic importance. To this has been added a strategic nutritional significance rapidly becoming accentuated and therefore more widely recognised. From the soil comes, directly or indirectly, by far the greater portion of our food and clothing and much of our fuel and shelter. Because it has always been available, like so many of nature's gifts, it has been taken too much for granted, has been frequently misused, and those asociated with it often despised. In most countries the farmer and the farm labourer respectively have yet, in fact, to gain the social status of the business man and his clerk, or the professional man and the mechanic, although to-day the tillers of the soil are without doubt of increasing importance in the scheme of human affairs. The application of a neo-Malthusian doctrine must be recognized: the greater portion of the world's population is underfed.

The study of the soil as a natural body —the science of pedology—is justified in the eyes of its protagonists not only by the above essentially practical considerations. To these they would add, as would the botanists and geologists, a desire to know more of the ways of nature for its own sake. The pedologists, too, realize the mutual advantage of both practical and fundamental objectives.

Pedology is the science of the whole soil; not of any particular part or quality thereof; but of the entire profile or section, from the surface to the underlying parent material. Pedologists are distinct from soil-chemists, physicists, mineralogists, and biologists. They use not only the data provided by these people but also the observable and determinable characteristics of the soil in the field. That is, they add soil morphology to this array of particular soil properties and coordinate and use them all.

To pedologists a soil is a soil only so long as it remains *in situ*: take it into the laboratory and it becomes a number of soil samples which lose some of their individual field characteristics and fail to exhibit their interdependence on each other in the soil profile. Many of the properties of soils have spatial and dynamic qualities which may be lost when the soil is removed from its environment and from its association with other nearby soils. No one, for example, has yet succeeded in taking a soil profile with its water relationships and soil atmosphere intact into

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the laboratory. There are pedological and agronomic relationships between different soils in the field which cannot be assessed by any laboratory technique.

The Soil Profile

Pedology depends on the recognition of the soil profile as an organized natural entity recurring from place to place in any one soil type with but minor variations. The profile presents, within limits, an elaborate but orderly ensemble of morphological, physical and chemical properties which to be appreciated to the fullest extent, must be studied and assessed together. The agronomic usefulness of a soil depends on all such properties, not on just a selected one or two. The soil profile is the basic unit in all pedological considerations whether of soil classification and mapping or of pedogenesis; the latter being that branch of pedology which deals with the development of the soil type as a natural geographic expression and its formation as a profile composed of a number of horizons or layers each with a different composition.

In the soil profile the upper horizons are most subject to leaching and to the accumulation of organic matter. For convenience they are termed *A* horizons. The next lower layers where deposition of leached material takes place are termed *B* horizons. The lowest where primary weathering occurs are called *C* horizons. These horizons have various characteristics in different soil types and it is a morphological assessment of these properties which is used in placing a soil in an appropriate place in a soil classification. The properties most frequently noted are the colour, texture, structure and consistence of each horizon; the occurrence of lime, gypsum, salt, or other materials; the distribution of organic matter in the profile, the thickness and arrangement of the horizons in the profile; the external and internal drainage of the soil; the occurrence and nature of water-tables; and the nature of the parent material of the soil. As indicated elsewhere by the writer (1953) an orderly appraisal of the above properties is an obviously important and objective assessment of the soil as an environment for plants of any character, or as an irrigation or engineering medium.

It has been shown by numerous pedologists that the above enumerated features of the profiles and their horizons reflect the role of climate, vegetation, fauna, relief, drainage, and parent material on the formation of a soil over the time of its existence. Moreover, these features modify and govern the nutrient status of a soil and determine its water relations with plants or its behaviour under engineering structures. It is this fact which makes such a doctrine of great practical importance in all forms of land-utilization, agricultural or otherwise.

Objectives of the Pedologist

Arising from the above basic considerations the pedologists have developed certain fundamental and practical objectives. They aim to develop a classification of soils based on all soil properties; to compile soil maps showing the occurrence of individual soil units or associations thereof; and to demonstrate clearly the relationships of different soils to different combinations of the genetic factors. In agriculture and other activities they aim to place the use of the soil on a basis conducive to permanent maximum production consistent with soil conservation. To achieve this they correlate crop growth and soil behaviour with soil profiles, and extrapolate this information to similar soils intended for development; or achieve a comparable result by interpretation of the morphological features of the soil profiles, particularly in regard to water relations and fertility status.

In this latter field of correlative and interpretative or, more briefly, agronomic pedology the last thirty years have seen the application of these principles to an ever increasing extent in many aspects of land utilization. It has caused a profound modification of previous practices in soil

husbandry, for example in the use of lime, fertilizer, and green manure crops; in the drainage, terracing and reclamation of land; in the investigation of animal and human diseases; in land assessment for taxation and other purposes; in engineering projects especially those involving buildings and paved surfaces; and in other scientific fields such as geomorphology and archaeology. In more recent years the pronounced emphasis on increased land settlement and food production has opened up a wide field of use of soil surveys. The agronomic interpretation of soil maps of virgin or underdeveloped areas in the selection of land, its development, subdivision, and selective utilization has become a commonplace approach. Many such projects involve the use of irrigation water and here again surveys have played a major part in the selection and development of such areas, and in concomitant channel location and design. In older irrigation areas these surveys have been the basis of reclamation projects associated with occurrences of salinity and perched water-tables.

To the pedologist engaged in soil mapping the vital and practical thing is the nature and behaviour of the soil in the field. This implies a marked distinction to many other forms of survey intended to aid in the use of the land, particularly those based wholly or in part on a survey of the virgin or existing vegetation. The pedologist emphasises that it is the soil which is cultivated and must be conserved, that the soil is the reservoir of plant and animal nutrients, that it is the soil which reacts with added fertilizer, that the soil determines what natural moisture will be available to crops and plants whether native or exotic and that the soil is the principal determinant in the utilization of irrigation water. These factors lead the pedologist to insist that in all forms of land-utilization connected with agriculture and forestry it is the soil which should be primarily investigated and surveyed.

Certain surveys are of a more basic character than others. Topographic, hydrologic, geologic, and soil maps, delineated where possible on accurate cadastral plans, provide the most fundamental information about any tract of land. Such surveys are directly useable, frequently without modification, by departments concerned with agriculture and forestry, and can be recast by other departments, as necessary, into other forms suitable for particular purposes, such as those concerned with land selection and development, soil conservation, engineering, land taxation, and irrigation. As pointed out in a recent F.A.O. publication (1953) it is only by such a functional arrangement that the expenditure of public funds on classification and mapping can be kept to an efficient minimum and repeated expenses on field work for temporary, narrowly defined, and unadaptable classifications be avoided. The ideal arrangement is for most departments to have appropriate sections for recasting and supplementing basic surveys, rather than to employ extensive staff to carry out special surveys of minimal use to other authorities. A convincing demonstration of the use of basic material is provided by the U.S.D.A. map (1952) entitled "Sound land classification rests on soil surveys. A group of maps based on soil survey".

Misuse of Natural Resources

A number of practices in land-utilization, some of them almost world-wide, are often undertaken in the face of rather obviously unsuitable conditions. In most countries the outstanding example of the disastrous result of following such a course is the incidence of soil erosion on both cultivated and grazed land. Because of overgrazing and crop rotations badly adapted to the soil on which they are pursued, damage has been severe, widespread, and permanent. Equally serious is the misuse of irrigation water and soil. There are unnecessary losses of water due to conveying it too far, frequently by-

passing good irrigable soils to serve inferior ones at a greater distance. The consequent loss of water by evaporation and seepage is greater than necessary, and the oft-encountered problem of using impermeable soils is a very difficult one indeed. Much better geographical planning of the use of soil and water resources is called for in the future. Another defect has been the lack of provision of adequate drainage from the outset in irrigation areas. Too frequently there has been a misguided waiting for increased salinity and high water-tables to develop before the necessary drainage has been installed; this in spite of the well-established fact that such troubles bring in their train secondary more difficult problems which are very costly to remedy. A proportion of such problems has been accentuated by the lack of strict control of watering on individual irrigation farms.

All these are reprehensible practices in the eyes of the pedologists anxious to have the soil and water resources of their countries utilized in the most efficient manner. This destruction and misuse of soil and water resources will unquestionably bring condemnation by posterity to a degree comparable with that which followed the malpractices which developed during the industrial revolution in England. The scars of erosion on our extensive arable and grazing lands and the sterile patches on our irrigation farms are the insignias of a new barbarism—the signs of man's avarice, incompetence, and culpable negligence in the utilization of the land.

Ultimately the obligation to see that the nation's soil and water are used to the greatest advantage for the greatest number of people must pass from the shoulders of the politically inspired administrator to the technically guided hands of the pedologist and his colleagues working in the spheres of plant and animal production. In the final analysis they will know best where to grow the different kinds of food and other primary products to the greatest social and economic advantage.

Conclusion

Bodily and intellectually pedology is not a comfortable and easy discipline. It calls for a knowledge of agriculture, physics, chemistry, botany, geology and climatology. It makes such demands upon one's muscular energy that few intellectuals find it an attractive field for any length of time. It calls for physical endurance, some forbearance of solitude, a mind in appreciative harmony with nature and easily adjusted to varying conditions, a considered judgment in approach to landholders, and an ability to mix with all kinds of people. There is a marked tendency for many with a nodding or short-lived acquaintance with the subject to air a certain superficial knowledge from the comfort of an armchair. One satisfying recompense for the active pedologist is the conviction that he is contributing in an ever-increasing degree to the welfare of the human race. As George Bernard Shaw put it, "This is the true joy of life, the being used for a purpose recognised by yourself as a mighty one".

References

F.A.O. (1953)—Agricultural Study No. 20, Rome. Soil Surveys for Land Development.

Stephens, C. G. (1953)—A manual of Australian soils. C.S.I.R.O., Melbourne.

United States Department of Agriculture (1952)—B.P.I.S.A.E. Sound land classification rests on soil surveys. A group of maps based on soil survey.

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THE TRAINING OF AGRICULTURAL EXTENSION WORKERS

By E. J. UNDERWOOD, R. R. PENNEFATHER
and
W. A. T. SUMMERVILLE

All advanced countries now recognise the need for agricultural extension services to convey to the practising farmer the findings of the research worker and to convey to the research worker the problems and the observations of the farmer. In the past, most of the extension work was carried out by men with little or no formal vocational training for their job but with a wealth of practical experience in the industry which they served. Such individuals have steadily been displaced by specially trained men and women. This has come as a consequence of technical developments in agriculture and changes in the farming community itself. Science and technology now have such a powerful impact upon farming practice that some training in the scientific principles underlying agriculture has become a necessity for an effective extension worker. Moreover, standards of general and technical education among farmers have risen to such an extent that the extension worker without equal or better educational standards is under a serious handicap.

The training of extension workers can conveniently be divided into two sections, pre-service and in-service training, although the nature and extent of each will clearly influence the other. As the State Departments of Agriculture have practically the sole responsibility for actually carrying out extension work they obviously also have the responsibility for in-service training. Pre-service training, on the other hand, is the function of the agricultural colleges and University Faculties of Agriculture.

Pre-service Training

Several of the State Departments of Agriculture still recruit a high proportion of their extension workers from the agricultural colleges, although the modern trend is for such workers to come from the ranks of University graduates in agriculture. Some Departments have recruited graduates entirely, or almost entirely, for more than 20 years. The movement towards the graduate extension worker has not been as rapid in Australia as a whole, as in U.S.A. or Great Britain due to the following three principal factors:

(i) A belief that the agricultural college diploma provides a more practical, "down-to-earth" type of training of more immediate use to an extension officer than the more academic training of the University.

(ii) The urgent necessity to increase extension staffs and the difficulty of obtaining sufficient University graduates interested in and willing to undertake extension work.

(iii) Pressure from the agricultural colleges, which see the Universi-

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The authors were appointed by the A.I.A.S. as a sub-committee to investigate the training of agricultural extension workers. This is the report which was submitted.

ties as a serious threat to their status and place in the whole field of agricultural education.

Australian agricultural colleges vary so much in the quality and quantity of their training that it is difficult to generalise; however, the standards of entry of the colleges are generally so low that the general educational background of the students is inadequate. Furthermore, the two or three year courses are heavily loaded with routine farm work and the class work emphasises current agricultural facts, opinions and techniques rather than the continuing scientific principles which underlie them. This results in the production of young men of great immediate usefulness, particularly when working with more experienced and highly trained workers, but, in most cases, they have not the technical capacity or flexibility of mind which allow them successfully to cope with the rapid and continuous advances in scientific knowledge in relation to agriculture. It is considered that these qualities are most likely to be found in University graduates in agriculture, whose general educational background is higher than that of the agricultural college students and whose training includes basic work in all the natural sciences and their contributions to agriculture. High level training of this type is essential for extension officers if they are to fulfil their proper role in an efficient service and if this service is to achieve the status which it deserves.

The various Australian University Faculties of Agriculture naturally and rightly differ somewhat in the emphasis which they give to certain aspects of their courses. All provide a broad four-year degree course with either a minimum of specialisation in the third and fourth years or none at all. The breadth of training provided is essential for the "general practitioner" type of extension worker who must be regarded as the key man in any modern extension service. Considerable criticism has been levelled at these courses, however, in that they are too orientated to research and that they fail to provide any training in the methods, techniques and procedures of extension. The essential function of the University is to give a sound scientific training. The more specialised training in research methods and procedures comes naturally in the post-graduate years at the University and is accepted as a proper University responsibility. Specialised training in the methods, techniques and procedures of extension can be given much more satisfactorily after employment by the employing agency as a part of in-service training. This is dealt with in the next section. Nevertheless, it is considered that the undergraduate training could be improved from the extension point of view by the inclusion, in the fourth year, of a course dealing with the importance, scope and organization of an efficient agricultural extension service and also with the managerial and economic aspects of farming. Such a course could do something to orientate the students' minds towards extension as a life's work, to raise the status of the profession relative to research and to impart more of the 'whole-farm" approach to extension activities.

In-service Training

In Australia, the nature and amount of in-service training naturally differs a good deal from State to State. Methods used have included staff meetings, conferences on defined subjects, discussions with specialist officers, Head Office letters, circulars and pamphlets. One of the best known of the more formal methods has been the two-weeks' residential course on extension principles and methods conducted by the N.S.W. Department of Agriculture. Also recent visits of State Officers to study extension in other countries have stimulated much interest in extension training.

IN-SERVICE TRAINING IN THE UNITED STATES.

In the United States, in particular, much clearer definition is now being given to the principles, purposes and methods

of in-service training, and an account of some of the prevailing ideas on the subject in that country could well precede further consideration of the position in Australia. A report by a committee of specialists and administrators on in-service training in the New York Extension Service, prepared in October, 1952, provides a good example, and we have summarised some of its main features as follows:—

1. *Objectives.*—The chief objective of in-service training is to help an extension officer to become an effective leader of the farming community. Such leadership is not automatically vested in his office. The development of able, effective extension workers requires training in all phases of their work, and if they are to grow professionally and meet ever-changing conditions, this training must be a continuing process. It is not enough for them to keep up-to-date with scientific facts applicable to the farming of a region. They must keep abreast of new developments in leadership and teaching techniques, including the handling of groups.
2. *Scope for in-service training.*—The training necessary for effective leadership should cover the following:—
   (a) Understanding of extension objectives, philosophy and organization.
   (b) Knowledge of the science and practice of farming.
   (c) Understanding the nature of research. The extension officer must have a receptive attitude towards research and recognise it as a live force constantly imposing changes on agriculture. He must acquire skill in the integration of new research findings to farm management and be willing to rely heavily on others to interpret and guide him in their application. He must be able to define problems for research.
   (d) Performing the educational job. The extension officer must be able to develop programmes for teaching, to teach effectively, to develop leaders, to organize for group action and to develop skill in indirect teaching. This implies that he must understand human behaviour and how it can be changed, and the use of modern teaching techniques and aids. He must also know some well-established principles and methods for securing group action. He must recognise that he is only one of many forces that influence farmers but he should know how to guide and use those forces without affecting his reputation as an authoritative and unbiased source of agricultural information.
3. *Media and methods of training.*—These include schools, written material, meetings, personal visits from specialists, and apprenticeship to an experienced officer. The planned training procedure should use a balanced combination of these methods.
   (a) Schools.—Formal training schools have several important advantages. Full and flexible use can be made of teaching techniques — group discussion, visual aids, forums and "work shops" — and the time of specialists is used efficiently. State-wide schools are primarily suited for subjects of broad interest and are particularly adapted to launching State-wide programmes or campaigns. Regional schools are suitable for more detailed consideration of local problems and necessitate less travel.

(b) Written material.....The forms this can take are fairly obvious and include personal correspondence with specialists, news notes or newsletters from headquarters, bulletins for farmers (which are also of direct value to extension officers) and articles in farm periodicals.

(c) Meetings and personal contacts.—Extension officers can learn by attending specialists' talks to farmers, by participating in industry groups, and particularly by participation in the planning and the discussion of results of regional field experiments and farm surveys on various phases of agricultural sociology and economics.

IN-SERVICE TRAINING IN AUSTRALIA

In most modern extension services increasing emphasis is being placed on the function of an extension officer as the leader of a farming community, and the principles and techniques he must follow to achieve this position. Many extension officers have not been sufficiently aware of this broader concept of their work or of the new body of knowledge now being built up and systematized regarding the extension process. Too often their views on extension principles and methods have been based on their own experience, which can only be limited. This can be corrected in the first place, by greater attention to extension principles in University courses of agriculture, as already outlined, and by greater emphasis on this aspect through in-service training.

In Australia, both aspects of training have suffered because very few specialists trained in extension have been available for teaching or objective appraisal of the situation. Consideration should be given to the appointment of such specialists to both Universities and Departments of Agriculture. Agricultural Extension has now attained the status of a subject in its own right, and its principles and methods should be widely discussed. More fundamental and academic treatment of extension at Universities need not in any way clash with more applied and domestic aspects properly treated by State extension authorities. There should, in fact, be abundant opportunities for collaboration between both, in the planning and conduct of pre- and in-service training. In time, it should be possible for Universities to provide post-graduate courses in extension along the lines, for example, of those being provided by Cornell.

This report has mentioned the stimulus that is being given to extension in Australia following the visits of State officers to study extension in other countries; such visits are considered to be well justified and further overseas training of key officers in extension is required.

At this stage of agricultural development in Australia there should be the fullest opportunity to discuss extension principles and methods, and conferences along the lines of the Extension Services Conference in Adelaide, 1953, under the auspices of the Standing Committee on Agriculture, should be held periodically for this purpose.

In quoting overseas experience in this subject, it is not intended to infer that all principles and procedures mentioned are necessarily applicable to Australian conditions or that, in fact, substantial progress has not been made by various States in several phases of both pre- and in-service training. Australia presents a range of rather unique features which must be considered in applying such principles, and must have some important contributions of its own. The size of some States, the scattered nature of farming and long distances for travel in many areas, present special problems. The use of regional teams of extension officers in New South Wales and some other States is an example of one way in which these problems may be met.

The most important present requirement for extension progress is to empha-

sise the concept of the extension officer as the leader of the agricultural development of his region, and the principles and techniques which both he and administration must follow to achieve this. This concept should mould requirements for pre- and in-service training and lead ultimately to the solution of difficulties which may at present affect the professional status of extension officers and the administrative conditions under which they work.

In drawing up this report we have been conscious of the fact that it represents an ideal which, like most ideals, will take some time to accomplish. In the interim the organization which will necessarily function will be at best something of a compromise between what is now existing and what is in our opinion required. This means essentially that, for some time, college diplomates will be employed in appreciable numbers in the extension services of some State Departments. In these circumstances we feel that a move should be made partially within the agricultural colleges, and partially within the State Departments, for special training in extension methods for Diploma men.

Where the duration of the course is restricted to two years it is quite obviously impossible to sacrifice anything of the curricula now in operation, and therefore any special studies in extension methods would be in the nature of a post-diplomate course. It could indeed be modelled somewhat on the same lines as we have visualised for specialisation within the Degree course. If this were done it is difficult to see what more the State Departments could do other than to ensure an adequate apprenticeship for new recruits. In the absence of specialization in the Colleges it seems to us that State Departments should conduct formal schools along just the same lines but in this case, as the men being dealt with would be beyond the normal trainee age and experience, such formal courses could be shortened and perhaps be of a more intermittent nature along lines which would be more acceptable in the general conduct of a Department.

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AUSTRALIAN EXPERIMENTS ON ARTIFICIAL STIMULATION OF RAINFALL

By E. G. BOWEN

Australia, with its vast arid regions, is a country which could derive enormous benefit from a successful method of inducing rain to fall artificially, and for this reason there has been extensive research and experiment in the subject during the last few years.

The work began with the conviction that the most likely method of arriving at a practical answer in a short time was to study the problem of rain formation in a fundamental way. The experiments were therefore designed in a manner which was likely to lead to a clear understanding of the physical processes which occur when different materials are injected into clouds. As this understanding grew, it was hoped that the knowledge could then be applied to some of the practical problems of the community. The plan is still in its early stages and this paper describes the progress which has been made to date.

Experiments on Single Cloud Cells

In following this plan, the initial experiments were concerned almost entirely with single cloud cells, in which the whole sequence of events could be observed and followed from an aircraft. The preferred condition for the experiments was one in which a number of cloud cells existed near one another, all of similar characteristics. In addition, the clouds should have reached their maximum development so that the chance of their producing rain by subsequent growth was small. Before seeding, a careful check was made by radar and otherwise to be certain that the clouds did not already contain precipitation elements. After seeding, the behaviour of the cloud which had been treated was carefully observed by comparison with surrounding clouds. In many of the experiments extensive use was made of both ground and airborne radar to check the first appearance of precipitation and to watch its subsequent growth.

In analysing the results, an experiment was considered to be successful if the cloud experimented upon precipitated out following seeding while adjacent clouds remained unchanged. The seeding was considered to be unsuccessful if no such precipitation occurred. The results were rejected if, for any reason, the adjacent clouds produced rain during the course of the experiment.

Dry Ice Seeding

About one hundred dry ice experiments were performed in the period 1947 to 1951. The experimental procedure and the results have been described in a number of papers, to which the reader is referred for further details. (Smith, 1949, Squires and Smith, 1949). The outstanding conclusion drawn from these experiments is that, given suitable cloud conditions, it is tolerably certain that seeding with dry ice produces rain which could not otherwise have fallen. A typical example of the result of seeding is given in the upper picture of Figure 3, which is a photograph taken underneath a cloud deck 25 minutes after an individual cloud had been seeded with 20

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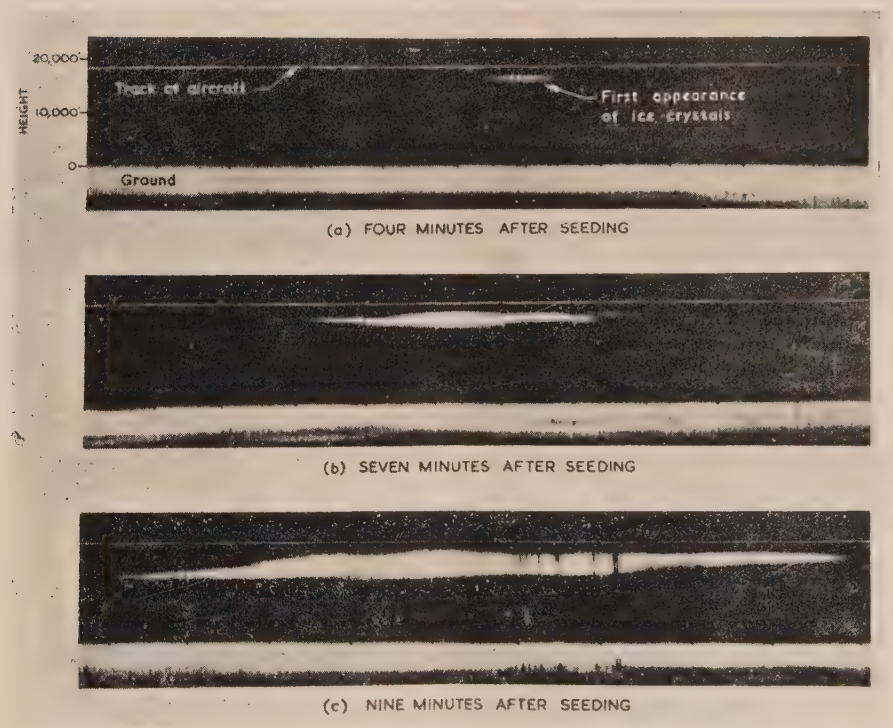
Precipitation falling from a cloud near Bathurst, New South Wales, 25 minutes after being seeded with 20 pounds of dry ice.



Radar pictures of the first appearance and the growth of ice crystals in a cloud after seeding with dry ice.

Acknowledgment to C.S.I.R.O.

Figure 3.

pounds of dry ice. Precipitation is seen to be falling to the ground from the seeded cloud, no other precipitation falling in the area. This experiment was performed on 25th August, 1948, the cloud thickness being 3,000 ft. and the clear air temperature at the top —7°C.

Perhaps the strongest evidence for the appearance of precipitation after seeding, followed by its growth and subsequent fall from the cloud, comes from airborne radar observations. A typical example is given in the lower part of Figure 3, which shows three radar cross sections taken vertically through a cloud 4, 7 and 9 minutes after seeding. In each picture the thin horizontal line at 18,000 ft. represents the track of the aircraft, and the diffuse echo just below the aircraft comes from the ice crystals. The ice crystals first appear 4 minutes after seeding with dry ice, growing rapidly and spreading through the cloud in the subsequent few minutes.

A sufficient number of experiments has now been performed to enable us to define fairly accurately the conditions under which useful falls of rain can be produced by the dry ice method.

(1) The chance of successfully producing rain from a given cloud is critically determined by the cloud top temperature. If a curve is drawn of the chances of success of seeding with dry ice against the clear air temperature at the top of the cloud concerned, a diagram similar to Figure 1 is obtained. This indicates that at temperatures of —7°C. and colder there is a 100 per cent chance of producing precipitation. At temperatures between —7°C. and 0°C. the chances of success fall off progressively, tending to zero at 0°C. At temperatures of approximately —15°C. and beyond the results lose their significance because of the high probability of clouds producing rain naturally beyond this temperature.

(2) The time at which precipitation will appear at the base of the cloud depends mainly on the thickness of the cloud. A curve relating these two quantities is given in Figure 2 and it is seen that the time for precipitation to appear consists of two parts: a gestation time of about 10 min. which is presumably required for the ice crystals to grow, followed by an additional time of about 1 min. for every 800 ft. of cloud, which is related to the rate of fall of the precipitation.

(3) The intensity of the precipitation from the base of the cloud increases with increasing cloud thickness.

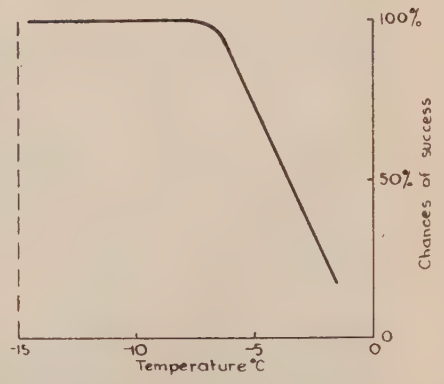


Figure 1.
The chances of successfully producing rain by means of dry ice, as a function of cloud top temperature.

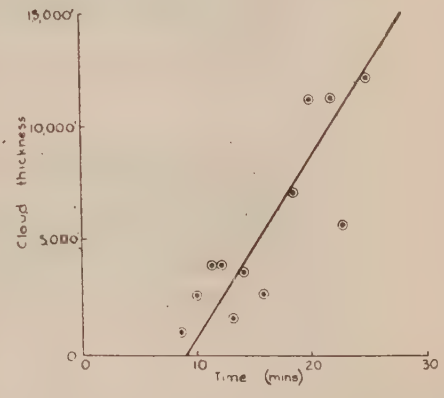


Figure 2.
The time after seeding at which precipitation appears from the base of a cloud, as a function of cloud thickness.

(4) The precipitation will just reach the ground if the height of the cloud base is double the cloud thickness. A considerable fraction of the precipitation will reach the ground if the height of the cloud base is equal to or less than the cloud thickness.

In successful experiments it is usual for the cloud concerned to precipitate out within a period of 40 to 60 min. of seeding, giving from 0 to $\frac{1}{4}$ in. of rainfall on the ground during that period. At the end of this time the cloud almost invariably disperses.

When atmospheric conditions are just right, clouds have been known to turn into cumulo-nimbus (Kraus and Squires) in which case they become regenerative, produce a large number of ice crystals of their own, and might give upwards of $\frac{1}{2}$ in. of rain over a longer period of time. This behaviour is by no means common and has occurred on only 3 or 4 per cent. of occasions.

A final observation, which is contrary to the views of Langmuir, is that in these experiments there was no case in which overseeding appeared to occur. The amount of dry ice used varied from 10 to 300 pounds on a single cloud cell and the amount of precipitation obtained appeared to increase with increasing quantities of dry ice.

Silver Iodide Seeding

Fewer experiments have been performed in Australia with silver iodide than with dry ice. The method of performing the experiments is generally similar to that with dry ice except that the aircraft either flies through the top of the cloud concerned or the silver iodide is dropped through it on a parachute flare. The quantity of silver iodide used varies from a fraction of an ounce to several ounces per cloud.

It has been found that at temperatures in the neighbourhood of —6°C. and —8°C. in clouds which are highly likely to produce precipitation with dry ice, no success has been obtained with silver iodide. In fact, only one successful experiment has been performed, when the cloud top temperature was —13°C. This is so close to the temperature at which the cloud might have produced rain naturally that the result is of very doubtful significance.

Although this series of experiments is still in progress, it can already be said with a fair amount of certainty that the behaviour of silver iodide is different from that of dry ice and that considerably lower cloud temperatures are required. This result is in line with laboratory experiments in the cold chamber, in which the critical temperature for growth of silver oidide appears to be between —4°C. and —6°C. as compared with —1°C. for dry ice.

The practical conclusion to be drawn from this result is that the number of occasions in nature which are suitable for silver iodide seeding are considerably fewer than for dry ice, and the increased rainfall to be expected is less.

Water Seeding

The above results refer to cases in which precipitation follows the introduction of ice crystals or ice-like crystals into the upper part of supercooled clouds. It is now quite certain that in many parts of the world, including Australia, much rain falls which does not have its origin in ice crystals. In these cases the raindrops grow by coalescence of cloud droplets. Detailed investigation (Bowen, 1950) shows that the necessary conditions for moderate to heavy rain to fall by coalescence are as follows:—

(1) The cloud must have an updraught which may be as little as one or two feet a second but which must persist for a period of 30 minutes or more.

(2) The cloud water content should be reasonably high and should approach or exceed 1 gramme per cubic metre.

(3) There must be a wide distribution of cloud droplet sizes at the cloud base or, alternatively, there must be a few large drops interspersed with the smaller cloud droplets. If this condition is met, the larger drops have an opportunity of falling relatively to the smaller ones and of growing by collision.

If, for any reason, this last condition is *not* met, clouds which satisfy conditions (1) and (2) might be induced to rain by introducing large drops into the base of the cloud. These might be either in the form of water sprayed into the base or of large condensation nuclei dispensed just under the base.

Experiments of this kind are being performed in Australia (Bowen, 1952) in which an aircraft flies through growing cumulus clouds 1,000 ft. above the base, spraying water at a rate of 100 lb. per mile. The spray consists of a wide distribution of drop sizes extending from cloud droplet size to a diameter exceeding 100μ. In clouds less than 5,000 ft. thick the predominant result is that virga fall within a few minutes of the spray being introduced, followed by rapid dissipation of the cloud concerned. In clouds exceeding 5,000 ft. in thickness, however, real precipitation, varying from light to heavy, has been obtained under circumstances which suggest that it was artificially induced.

These experiments are only in the preliminary stage but give real hope that rain can be induced to fall artificially from convective cells by the introduction of either large drops or large hygroscopic nuclei into the base of the cell.

Experiments over an Area

Dry Ice and Water Seeding

From the foregoing there is little doubt that dry ice seeding of supercooled clouds or water seeding in the base of convective cells can produce substantial amounts of precipitation which would not otherwise have fallen, provided the conditions are right. The question then arises of how often conditions are suitable over a large area and a long period of time. This will determine the extent to which the average annual rainfall of an area might be increased by artificial means.

Any estimate of this kind is necessarily an approximate one because of the lack of data on cloud-top heights and upward air velocities, but a rough calculation made for south-eastern Australia suggests that an increase of 5 to 10 per cent. in annual rainfall might be obtained at the very outside. The cost of obtaining this increase, since it involves seeding from aircraft, is such that the process is most unlikely to be an economical proposition.

Very little experimental work has been done to check these figures but during some experiments of limited duration over a hydro-electric catchment area in Tasmania in 1950, using dry ice seeding, the increased rainfall obtained certainly did not exceed the amount quoted above.

Silver Iodide Seeding

The alternative method of cloud seeding by means of silver iodide generators on the ground has attracted a great deal of attention in the United States because it gives promise of providing means of dispensing active nuclei over a large area at relatively small cost. Unfortunately, as many of the experiments have been performed without adequate controls, there is a great deal of doubt whether additional rainfall has in fact been obtained. In addition, the efficiency of the generators themselves is in question because—

(1) there is a possibility that the silver iodide nuclei lose their effectiveness soon after leaving the generators;

(2) it has not yet been shown with certainty that the nuclei reach those parts of the cloud where they might become effective.

In order to check some of the claims which have been made regarding silver

iodide dispensed from ground generators, a series of experiments was performed at Hay in New South Wales in July, August and September, 1951. The region is particularly suitable for an experiment of this kind, as the normal distribution of rainfall is remarkably uniform over a distance of about 100 miles in every direction. The average annual rainfall increases from 11 in. in the western part of the area to 17 in. in the eastern part, the isohyets running approximately north and south. The area is also well covered by rain gauges, readings being available once a day from upwards of 90 stations. The silver iodide was dispensed from a ground generator similar to those used by commercial operators in the United States, the amount of silver iodide used varying from a fraction of an ounce to several ounces per hour. The generator was run at times which were conducive to rain formation and a comparison was made of the rainfall in the downwind sector as compared with that in adjacent sectors. The result was that over the three months period there was a small percentage increase in the rainfall in the downwind area, but this was smaller than the normal variability.

The analysis has so far been confined to distances of 100 miles from the ground generator, so that no information is at present available on possible long distance effects.

Possible Economic Importance of Rainmaking

It appears, therefore, that methods are not yet known by which large-scale modification of rainfall can be accomplished in an economical manner. Until such methods are discovered the practical importance of artificial rain-making appears to depend on the existence of critical situations, either relating to the time at which rain is required to fall or to its geographical distribution. These situations are most likely to be found in countries with a marginal rainfall. The clearest example is in the monsoonal north, where large clouds appear for a few weeks before the wet season begins. If these clouds could be made to rain, the season would not only be lengthened, but would become more reliable, and any crops could be sown with confidence. Elsewhere in Australia it has been found that about half of the periods of seriously deficient rain are accompanied by normal amounts of cloud. It would be helpful to have exact information from the agriculturists on the critical periods when a small amount of additional rain is most needed, and when, therefore, the expense of rainmaking would be most justified. Early spring in the southern wheat-belt is a well-known example of such critical periods.

Another example of a different character is found in areas which depend for their water on runoff from comparatively distant mountain slopes. A large proportion of this water is lost by seepage and evaporation and there are frequently critical situations near the end of the runoff region. In these cases a comparatively small increase in precipitation over the mountain slopes could lead to a very substantial increase in the available water at the end of the runoff.

It has been suggested that rainmaking in one region might rob other areas lying further on in the path of the depression; while this is theoretically possible, there is no evidence available as yet.

References

Bowen, E. G. (1950)—*Aust. J. Sci. Res. A.*, 3: 193.

Bowen, E. G. (1952)—*Quart. J. R. Met. S.*, 78: 37.

Kraus, E. B. and Squires, P. (1947)—*Nature*, 159: 489.

Smith, E. J. (1949)—*Aust. J. Sci. Res. A.*, 2: 78.

Squires, P. and Smith, E. J. (1949)—*Aust. J. Sci. Res. A.*, 2: 232.

THE FLOUR STRENGTH OF AUSTRALIAN WHEAT VARIETIES

By A. J. MILLINGTON and E. REMILTON

The capacity of wheaten flour to produce an aerated loaf is a characteristic possessed by only one other commercially cultivated plant, cereal rye (*Secale cereale*). The property of retaining the carbon dioxide respired by the yeast has long been associated with the protein (gluten) fraction of the flour. It varies not only with the amount of gluten in the flour, but also with its "quality" or tensile strength and, over the years, a trade terminology has developed which designates as "strong", samples of wheat which give large well aerated loaves. "Weak" wheats give smaller and hence denser loaves that are less palatable, but this type of flour is preferred, however, for biscuit making. By blending wheats the miller can produce flour with a relatively constant strength and, since it enables bakehouse procedure to be standardised, this uniformity has become of increased importance with the mechanisation of baking. Adequate strength is usually associated with greater "tolerance", a term used to denote a capacity to produce a satisfactory loaf despite departures from optimal treatment during one or more of the bakehouse procedures.

Since Australian grain ranks as one of the weaker wheats in world trade, it is generally used overseas in blends rather than for milling directly into a baker's flour. On the world markets Australian wheat prices have been influenced by transport costs and the supply of suitable wheat in the same baking class, so that in some years Australian wheat has commanded a higher price than much stronger Canadian grain, but usually the position has been reversed. In Australia the grain milled for home consumption is drawn largely from the regions which, because of soil or climatic factors, produce flour with a relatively higher protein content and hence greater strength. To some extent, however, millers buy strong wheat for blending purposes and pay the grower a premium for it. The premium is necessary because, over much of the Australian wheatbelt, the stronger varieties by repute give lower yields.

The Assessment of Flour Strength

Although variations in strength can be expected to express themselves in terms of loaf volume, the baking test has many disadvantages as a means of evaluating samples. It requires a fairly large quantity of flour, and the result will vary with the skill of the baker. Attention has, therefore, been given over the years to developing alternative methods for measuring flour strength.

Farrer and Guthrie, working in Australia, supplemented the baking test with estimates of the gluten percentage and "water absorption". Strength was expressed as the number of quarts of water required to dough up one sack of flour.

During the early 1930's criticism of Australian wheat stimulated the State Departments of Agriculture to review their breeding programmes and to adopt the more efficient methods of measuring flour strength, which had been developed to supplement the "water absorption"

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Copies of the full data and analyses used in this article are available from the authors.

and "dry gluten" estimations then commonly used. During the last twenty years some Australian wheat breeders have based their selection of crossbreds principally on the results from two of these methods, the Farinograph and Pelshenke tests. These are representative of the two groups of tests, "physical" and "non-mechanical" respectively, which can be used to assess "flour strength" and other characteristics independently of a baking test.

The Farinograph, a physical test, is used to assess many attributes in doughs but the "strength figure" used in this study records the amount of energy required to break down the structure of the dough by over-mixing; this practice is often necessary in U.S.A. and Canada where very strong flours are used. The Farinograph "strength figure" is the time in minutes for the dough to fall below a standard consistency. The test requires 1 lb. of grain and is made on flour so that milling is a necessary supplementary process. This limits the number of samples which can be tested by one operator to about six per day. Another machine which records similar physical properties of flour doughs is the Swanson Mixograph. This machine uses wholemeal and because of its smaller grain requirement is better adapted to the requirements of wheat breeders.

The Pelshenke test, a non-mechanical test, requires less than an ounce of grain and is made on wholemeal so that, with technical assistance, one hundred or more samples can be tested each day by one operator. The principle of the Pelshenke test is to break down the dough by kneading it with a concentrated yeast suspension. The "Pelshenke time" is the period in minutes from immersion of the doughball in water at a controlled temperature until it is disintegrated by the carbon dioxide respired by the yeast. Stronger wheats give longer Pelshenke times (Samuel, 1938).

Other dough testing machines now used to assess flour strength in Australia include the Alveograph and the Extensimeter.

THE RELATIONSHIP BETWEEN TESTS FOR FLOUR STRENGTH

Samples grown in one place and having comparable yields have enabled us to make an introductory investigation of the relationship between the Farinograph and Pelshenke tests for the variety Bencubbin. These indicate that whereas the Farinograph strength figure (minutes) increases almost linearly with dry gluten, the regression of Pelshenke time on dry gluten shows highly significant deviations from linearity. These deviations do not, however, appear to form any pattern. One possible cause of the variation lies in the fact that these samples have been stored for differing lengths of time, and the Pelshenke time normally increases with storage (Samuel, 1938).

Worzella (1934) stated that the standard error of a Pelshenke time is proportional to the time itself and hence the logarithm of the time should be used in calculations. On investigating the results of 250 triplicate tests, no indication of such a relationship was found, and hence the times themselves have been used in all calculations discussed. Significance tests, however, have been modified slightly, as the times did not follow the normal distribution closely, but showed an unusually large number of observations clustered near the centre of the distribution.

The regressions of strength figure on Pelshenke time are not homogeneous for different varieties. i.e., the rate of increase in the strength figure with increments in the Pelshenke time varies with the variety. This implies that the two tests do not measure the same flour quality characteristics, since, if this were so, variety would make no difference to the relationship between the two tests.

For any one variety, dry gluten per cent. and Pelshenke time may be used to give a reasonably good prediction of

strength figure. Formulae for making this prediction (calculated from W.A. data) together with limits of the error to be expected over the range of dry gluten and Pelshenke time observed for the different varieties, are shown in Table I. Such a table enables the results from any one test with a known variety to be checked, or the Farinograph strength figure, which is expensive to determine, to be calculated from the results of the simpler tests.

The Varietal Position in Australia

In reviewing the achievements of Australian wheatbreeders, Macindoe (1951) states, "during the past 15 years high yield and baking quality have been combined to a higher degree than formerly in wheats with a limited usefulness. Wheats of good quality such as the Eurekas, Fedwab 1, and later Gabo, Charter and Yalta increased, largely because of high yield, to occupy together about 90 per cent. of parts of the northern wheat areas in New South Wales. . . . because of the larger areas of the Eurekas and the mounting acreages of Gabo, Charter, Yalta, Celebration and Kendee, between 1945 and 1948 the proportion of very strong and strong wheats has more than doubled.

". . . strong wheats have risen from 8.75 per cent. to 23.9 per cent. of the South Australian wheat area between 1947 and 1949, while in Victoria the extension of Pinnacle and Diadem gives some encouragement. However, in South Australia, in Western Australian, and in southern New South Wales, varieties of weak or very weak baking quality preponderate . . .

"However, reviewing the present Australian variety picture, it must be admitted that plant breeders have made relatively little progress in combining high yield and good quality in varieties which are at present commercially important over wide areas of the Commonwealth. Indeed, of the six leading varieties grown in 1948, Quadrat and Gluclub can only be classed as very weak and Bencubbin, Bungulla and Insigna as moderately weak flour wheats. Only Gabo, which occupied 4.8 per cent. of the wheat area, can be considered really satisfactory in baking quality."

Since this statement was published, the varietal position has changed markedly in South Australia where Gabo in 1952-53 accounted for 23% and medium strong varieties, including Gabo, constituted 42% of the total acreage. In Victoria the acreage of Pinnacle increased in the 1953-54 season to 21% of the total.

The 1951-52 season is the most recent for which complete varietal statistics are available for the whole of Australia. An analysis of the fifteen leading varieties

TABLE I.

Prediction Formulae for Strength figure using Dry Gluten % and Pelshenke time and errors to be expected.

Variety	Formula (g = dry gluten %. p = Pelshenke time)	Half 95% fiducial range *at mean*, i.e., 19 times out of 20, true S.F = calculated val. ± this figure	Half 95% fiducial range at *an extreme pt.* (i.e., D.G. & P.T. very high or very low)
Bencubbin	S.F. = —1.167 + .493g + .0373p	± .105	± .304
Kondut	S.F. = —4.813 + 1.030g + .0570p	± .246	± .915
Charter	S.F. = 0.393 + 0.710g + .0549p	± .715	± 1.890
Eureka II	S.F. = —5.313 + 1.018g + .0650p	± .625	± 2.005

which together account for 78.8% of the Australian acreage gives the area sown to "very weak" wheats as 14.9% of the total, "weak" 36.7% and "medium to strong" 27.2%. The variety Gabo accounted for 8.3% of the total and was the most extensively cultivated medium strong variety.

SOIL FERTILITY AND FLOUR STRENGTH

Apart from the approach of improving flour strength by breeding inherently stronger varieties, considerable emphasis has been given during the last decade to the influence of soil fertility, an aspect which Farrer stressed in his discussions of the problem. It was shown at Merredin Research Station (Western Australia) by Samuel (1945) that a suitable pasture-crop rotation gave not only a higher yield but also the grain protein and hence the flour strength of the grain was superior.

At much the same time Thomas and Millington (1945) remarked on the basis of investigations at the Wongan Hills Research Station "that the inherent capacity of crossbreds to yield flour of satisfactory strength is of little value unless soil fertility also received attention".

Although the grain produced in northern New South Wales and Queensland is regarded as being of adequate and even of premium strength, its continuing high quality is nevertheless dependent on the maintenance of soil fertility. It has been shown recently by Bissett and Andrew (1953) that on a heavy black soil of the Darling Downs (Queensland) an application of 3 cwt./acre of sulphate of ammonia gave highly significant increases in grain yield and flour protein.

The position relating to this aspect of the problem of improving flour strength has been reviewed in some detail in this Journal by Sims (1953).

In a recent study E. R. Watson (1953) obtained data which suggests that a very substantial increase in soil fertility is required in some districts before the grain protein is raised. It would appear, in fact, that with some varieties yield can be doubled without an appreciable gain in protein. The differential response of varieties to gains in the nitrogen status of the soil is discussed elsewhere in this Journal by Reeves and because of the increased use of pasture legumes in farm rotations it is an aspect which appears to merit detailed research.

Since varietal flour strength may be improved by—

(a) the production of varieties which have protein of better tensile "strength", or

(b) by the production of varieties having the capacity to consistently contain relatively more protein, or

(c) by increments in both of these genetic attributes, it is important to make some differentiation between the means for achieving improvement by breeding.

If strength is to be increased by the cultivation of varieties with a higher protein content then these must have the capacity to produce more protein per acre otherwise the yield of grain will be reduced. Consequently, as protein per acre is fundamental to an understanding of the physiology of producing grain of better flour strength, it is considered in some detail in this review.

Protein per Acre

SOUTH AUSTRALIAN DATA

The South Australian Departments of Agriculture and Chemistry have supplied data giving the yield in bushels per acre, the flour protein per cent. (Kjeldahl nitrogen x 5.7) and the Farinograph strength figure for their yield trials over the period 1938-1951. The yield and protein percentage enable the protein per acre to be calculated.

Representative centres in the main wheat growing districts were selected for

these yield trials (Cook and Farquhar, 1946).

The varieties grown included in the early years, Bencubbin, Early Gluyas, Dundee, Ford, Nabawa, Ranee 4H, Waratah and Sword, and later Warigo, Rapier, Javelin, Scimitar, Dirk, Insignia, Gabo, Charter, Glenwari, backcrosses of some of these varieties with Gabo, and other varieties not included in the analyses discussed below.

WEST AUSTRALIAN DATA

The West Australian Department of Agriculture supplied data from yield trials carried out at their Research Stations in the years 1944-49. Varieties considered in the analyses are Bencubbin, Koorda, Charter, Bungulla, W.19, Kondut, Eureka, Frisco, Wongoondy, Yalta, Gabo, Kendee, Celebration, Dowerin and some unnamed varieties bred at the Merredin Research Station.

STATISTICAL ANALYSES

For each year the figures of protein per acre for the varieties grown in several places have been subjected to analysis of variance. A typical set of figures and an analysis is shown in Table II. It has not been possible to carry out analyses covering a series of years of any length because of changing varieties, and lack of data, for some centres in some years.

The analyses possible on the W.A. data have been somewhat confined in scope, as few varieties have been grown at three or more Research Stations in any one year.

QUEENSLAND DATA

The Queensland Department of Agriculture and Stock has supplied figures from a wheat variety trial, conducted at Hermitage Regional Experimental Station in 1948-49, on two sites chosen to represent high and low soil nitrogen status.

TABLE II.

Protein lbs. per acre South Australian data, 1950-51.

CENTRE	Bencubbin 48	Warigo	Javelin 48	Scimitar 48	Dirk 48	Insignia 49	Gabo	Glenwari	Total
Roseworthy	148	110	101	106	130	101	76	83	855
Urania	142	177	169	174	194	192	172	164	1384
Booleroo Centre	150	148	158	150	134	143	136	142	1161
Sandalwood	46	38	51	58	39	46	42	40	360
Turretfield	94	134	125	116	122	128	115	109	943
Minnipa	101	95	94	82	99	98	94	94	757
Balaklava	95	110	103	114	121	116	132	92	883
Total	776	812	801	800	839	824	767	724	6343

Analysis of Variance.

Variation due to	Degrees of Freedom	Sum of Squares	Mean Square	Variance Ratio
Varieties	7	1,325.27	189.32	1.03 n.s.
Centres	6	77,290.61	12,881.77	70.02 *
Interaction	42	7,727.10	183.98	
Total	55	86,342.98		

n.s.—Indicates not significant.
*—Indicates significant at the 0.1% probability level.

RESULTS

In general, the variety effect for one year, when tested against the variety-place interaction for that year, has been not significant, i.e., the data does not in general give any evidence that the varieties considered differ in the average protein per acre produced in any one year at the group of places under review.

Certain exceptions to this generalisation do occur. In the South Australian series, significant varietal differences appear in 1946-47, and 1947-48. In these years, the experimental plots were badly affected by rust and most of the variety difference can be accounted for by the higher protein per acre produced by Warigo, the only rust resistant variety grown in those trials. The only other significant result in the S.A. series occurred in 1951, when Insignia 49, Dirk 48 and Gabo gave greater protein per acre than the remaining varieties ($p < 5\%$). This effect, however, was not consistent at all places, suggesting that it may be due to chance.

For the West Australian data there is no significant effect of variety on protein per acre in 13 of the 16 cases examined (in most years there were 2 or 3 separate trials, the varieties being grouped according to maturity). Of the 3 exceptions one may reasonably be assumed to be a chance effect, since five other analyses involving the same varieties showed no significant differences. In the other 2 cases, the rankings of the varieties concerned change. As they are derived from three stations only and as no general cause for the significant results is apparent, it is difficult to assess their importance.

The analysis of the Queensland results showed no significant differences in the protein per acre between the twelve varieties in the trial.

CONCLUSIONS

The data discussed above were not collected originally for the present purpose, and hence no final answer can be given as to whether some varieties produce more protein per acre than others. It is possible that some varieties may, under certain soil and climatic conditions, prove superior to others. However, except in extraordinary circumstances such as a rust epidemic *the data strongly suggest that, over the range of soil and climatic conditions of a State, the protein produced per acre does not vary significantly from variety to variety.*

Flour Strength per Unit of Protein

Since the withdrawal of nitrogen from the soil appears to be on the average relatively constant regardless of variety, it is important that the maximum strength be developed per unit of protein present in the grain. This is the aspect of the flour strength problem which has received attention from Australian wheatbreeders.

In view of the general association of the grain protein with flour strength and water absorption, the regression equation affords a means of studying the various relationships in quantitative terms. Having thus established generalised relationships, comparisons can be made between the varieties over a wide range of environments.

The regressions on protein percentage of three measures of flour strength, viz., "water absorption", "Pelshenke time" and "strength figure" are shown in Figures 1-4. Table III compares the slopes of these lines. i.e., the average increases in the measures of flour strength per unit increase in protein percentage. Over a protein range of 6.7%-14.3%, Early Gluyas gives a non-significant regression of strength figure on flour protein, and hence increases in protein level do not in general improve the strength figure for this variety. For Comeback also, where the wheat protein range of samples tested was 9.5%-17.1%, the regressions of both Pelshenke time and strength figure on wheat protein percentage are not sig-

TABLE III.

Slope and correlation coefficients of regressions of 3 measures of flour strength on protein content.

Variety	Water Absorption		Peishenke Time		Strength Figure		No. Samples
	Slope	r	Slope	r	Slope	r	
W.A. flats, as dry							
wheats:							
Marquis							
Ruby							
Red Bobs							
Reward							
Garnet B							
Comeback							
S.A. flats, as new							
wheats:							
Early Gluyas							
Gluyas							
Hercules							
Gluyas							
Insignia							
Reward							

Values n.s., etc. after the values indicate that the regression is not significant at the 5% probability level. Values with an asterisk are significant at the 5% level, those with two asterisks at the 1% level.

n.s. indicates not significant.

wheats. The main strength factor, and Peishenke time were 32.5 and 178 units respectively for this variety. Such data suggest that these tests may be of limited value with strong flour varieties such as Comeback.

For all three measures of flour strength, significant differences appear among the slopes of the varieties tested. This indicates that the response to varying of flour strength to increments in protein is a varietal inherent characteristic.

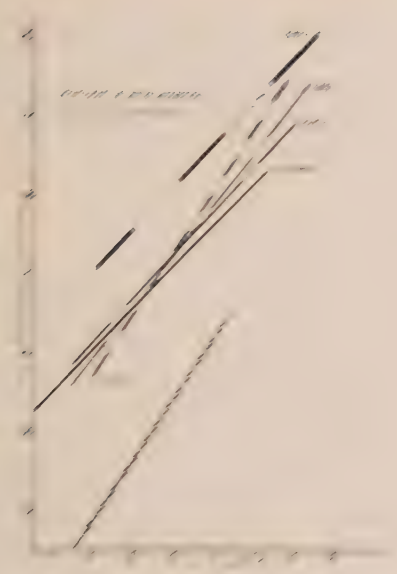
Moreover, since the varietal pattern is not the same for the three tests, it appears that these tests measure different flour strength characteristics. In particular, "water absorption" gives very different results from the other two tests. The water absorption of W.19 is low, while the other tests class this variety as being of medium strength. The high figure for Cabo, particularly at the lower protein levels, is also distinctive. This characteristic may be derived from its Persian parentage.

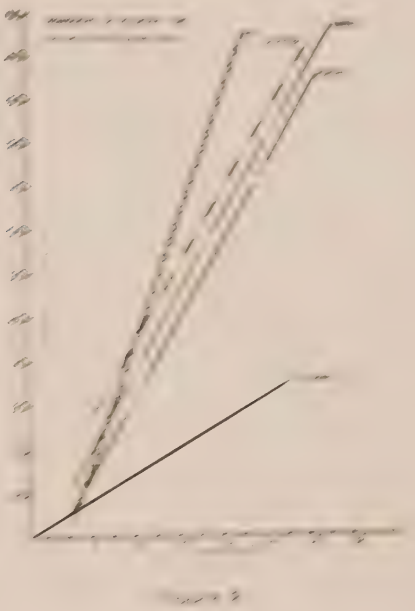
The regression lines must be considered in conjunction with the protein level existing in each variety under comparable conditions. Thus from the South Australian data, it was found that Insignia and Reward had very similar protein contents when grown under the same conditions, yet from Figure 4 it is clear that Insignia has a better strength figure at each level of protein. Consequently it will usually produce stronger flour, while yielding as well as Reward.

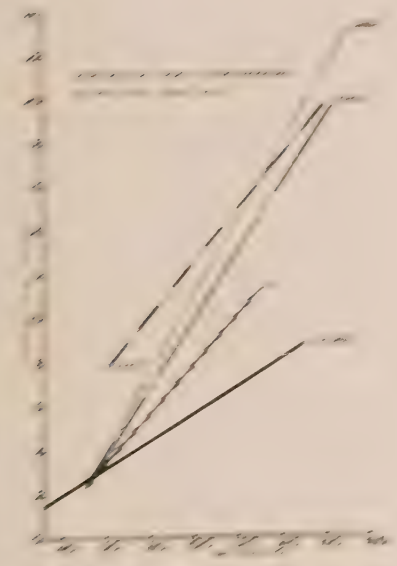
The graphs also indicate that a variety such as Schomburk only shows superior flour strength at comparatively high levels of protein, so that its cultivation cannot be recommended for districts which normally produce grain with a low protein content. Once a critical level of about 12% protein has been reached, its high efficiency in terms of strength per unit of protein makes it a most desirable variety. The capacity of inherently strong varieties to raise the flour strength of grain from any region must be considered in relation to these data.

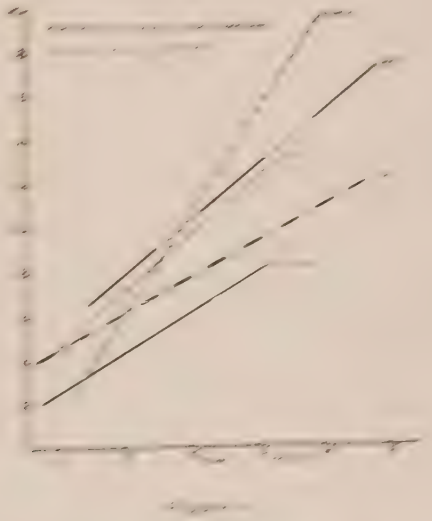
The Genetics of Flour Strength

Once the basic measurable attempts have been made to adapt every wheat









evidence that mixtures grown as a crop differed in strength from blends obtained by mixing the same lines grown separately but under identical conditions. This behaviour of separate varieties grown as mixtures appears to parallel the attempts of many breeders to combine the yield-flour strength characteristics in one variety by cross-breeding and selection.

The endosperm of the wheat grain has a different origin to the embryo in that it is the product of the union of two haploid nuclei from the egg apparatus with one haploid nucleus from the pollen tube. The initial endosperm cell, therefore, contains three sets of chromosomes whilst the embryo has only two. Consequently the grain of an F_1 plant of a cross between two varieties differing in only one gene will be a mixture having four genetically different endosperms. Moreover, the complicated nature of the endosperm nucleus is known to cause irregular cell division and this makes it difficult to conduct genetic studies based on normal segregation and re-combination of parental genes.

It does permit, however. a direct approach to the study of the inheritance of flour strength since the endosperm of the grains obtained by means of reciprocal crosses will have different genetic constitutions. The mother plant will contribute two sets and the pollen one set of endosperm genes. Worzella (1934) suggested that the flour strength of the F_1 seed could be calculated from the logarithms of the parental Pelshenke times and this approach has been used also by E. R. Watson (1953) who worked with three Australian varieties. Both investigations support the hypothesis that the "strength" genes behave quantitatively and reciprocal crosses have, in consequence, different Pelshenke times. However, as pointed out elsewhere in this article, Worzella's use of a logarithmic transformation of the Pelshenke times is open to criticism. Nevertheless, it merits further detailed investigation as, by using one variety as a genetic constant and crossing it with interesting material, an understanding of the heredity of flour strength may be achieved.

GENETIC STUDIES

Biffen and Engledow (1926), early in the present century, attempted to study the inheritance of flour strength in a cross between a weak, soft flour, English variety and Red Fife. In the variety Burgoynes Fife derived from this cross they showed that flour strength was inherited independently of the red grain colour. In the second generation they obtained 151 translucent grained plants and 49 starchy types, giving a simple 3:1 ratio. The experimenters remark, "The chewing test (to estimate gluten content and quality) on a number of small lots confirmed the eye judgments and so made it appear probably that strength was dominant to weakness".

In the cross (Gluclub x Eureka I) the second generation progeny gave three translucent grained plants to each starchy one and when these are graphed separately (Figure 5), it is noticeable that their flour strengths are markedly dissimilar. This is reflected in their mean Pelshenke times.

TABLE IV.

Second Generation Gluclub X Eureka I crossbreds, Wongan Hills Research Station.

Starchy Grained	Translucent Grained
53 minutes	64 minutes
Diff. for significance (P = 0.1)	9 minutes

—Millington (1942).

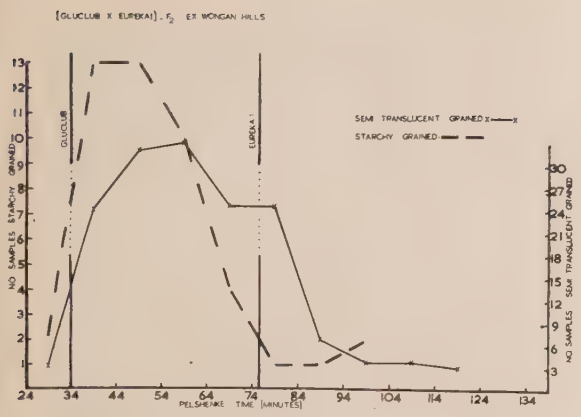


Figure 5.

This association of flour strength and vitreous grain is consistent with the results of Biffen and Engledow and may be due to linkage between one of the "strength" genes and the gene for translucent grain. However, Breakwell and Hutton (1939) have shown an association for Dundee between grain translucency and protein content, so that the superior performance of the translucent grained segregates is probably due to their having a higher average protein content.

Worzella (*op. cit.*), who pioneered the use of the Pelshenke test for genetic studies of flour strength, suggested that in the cross Trumbull x Michikof three multiple alleles could be identified. In a later study Worzella (1942) suggested that a weaker variety, American Banner, differed from Michikof in respect to four genes for gluten strength.

Somewhat similar data (Millington *op. cit.*) are available from two crosses studied in Western Australia.

The distribution (Figure 6) of the flour strength of the F_2 progeny of the cross Sutton x Eureka I indicates considerable transgressive segregation giving a large number of plants with much better strength than the stronger parent, Eureka I. This implies that more than one factor pair is involved.

However, in the cross Gluclub x Eureka I, little transgressive segregation occurred in the second generation, indicating that Gluclub possessed few genes for strength not present in the complement of Eureka I.

When Gluclub was introduced it was stated "that the Clubhead varieties are less strong than the lax eared ones now in general cultivation". The possible linkage of the clubbed head and weak flour is a matter of considerable importance to the plant breeder. However, an examination of the (Gluclub x Eureka) F_2 (Table V) ex the Wongan Hills Research Station showed that there was no association between these characters.

TABLE V.

(Gluclub x Eureka)	Mean Pelshenke Times
Lax-eared Type	Club-eared Type
60 minutes	62 minutes

The difference is not significant.
—Millington (1942).

Discussion

Although Sims (*op. cit.*) in reviewing trends in soil fertility, has cited evidence to suggest that over much of the Australian wheatbelt soil fertility is declin-

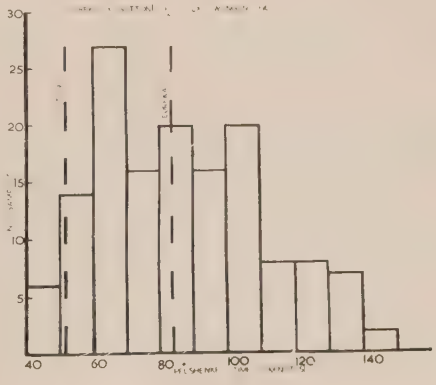


Figure 6.

ing, yield per acre has not decreased to a similar degree. Many factors, such as better farm machinery, have contributed to the maintenance of yields, but a major contribution appears to have been made by the wheat breeder.

Data from a survey by Cook and Farquhar (1946) are given in Table VI. These are from trials at six representative centres in the South Australian wheatbelt.

TABLE VI.
Average Yield and Protein Contents (1938-43).

Variety	Date of Release	Yield (bush./ac.)	Protein %
Gluyas (Early)	1894	16.5	9.7
Nabawa	1915	18.3	9.0
Bencubbin	1929	18.9	8.7

These data suggest that yield has been maintained in some instances by developing varieties which contain less protein, and therefore have a lower soil nitrogen requirement. Despite this decline in protein content, wheat breeders, by increasing the strength per unit of protein, have been able to maintain and even improve flour strength over the farmer selected varieties such as Gluyas. As pointed out above, Javelin, from South Australian data, normally has a similar protein content to Bencubbin, yet produces flour of superior strength.

It is considered that regression equations as quoted earlier in this paper may be of assistance in reducing the empiricism associated with breeding for maximum protein efficiency.

Moreover, the increasing use of leguminous pastures in the Australian wheatbelt makes it very important to determine whether there is a differential response of varieties to higher levels of fertility. Studies of this type have been discussed by Raw (1951) while the results of several experiments are reported elsewhere in this issue by Reeves.

Although it is now accepted that the influence of climate on flour strength must be considered in relation to the supply of available nitrogen in the soil, *time of planting* can influence the protein content as well as the yield. This is indicated by the following data (Table VII) for the variety Gabo grown at Roseworthy College in 1948.

TABLE VII.
Time of Planting Trial, 1948.

	Planting Date			
	May 4	May 27	June 25	July 23
Flour Protein % ..	9.0	9.7	11.0	11.0
Yield bus./acre . ..	24.2	31.6	37.1	21.2

In view of the frequent association of flour strength and grain translucency, it is of interest that the starchy grained variety Javelin is equal to Gabo in increments of strength per unit of protein. The translucent grained varieties tend to mottle as their protein contents decrease and it has been suggested by Breakwell and Hutton (1939) that this could be used as a means of visual classification in a wheat marketing system.

However, the relatively high water absorption at low levels of protein of the translucent grained variety Gabo merits detailed investigation to determine its genetic associations.

Apart from its association with flour strength, increasing the protein percentage is believed to improve the thiamin content and the keeping quality of the loaf. Increases in the protein content could well be supplemented by the addition of milk protein (Lee, 1952). Such changes in the composition of the loaf would greatly improve both its nutritive value and its keeping quality.

Summary and Conclusions

Flour strength has been defined, and several methods of measuring it discussed. It has been shown that the tests considered in some detail, viz., water absorption, Farinograph strength figure, and Pelshenke time, do not always measure the same flour strength characteristics.

The genetic and agronomic aspects of the problem have been discussed.

In considering over a wide range of soil and climatic conditions the protein per acre produced by a number of varieties evidence has been brought forward to suggest that no variety shows consistent superiority in one year.

This conclusion requires consideration when determining the methods for improving the flour strength of Australian wheat. The selection of varieties of relatively high protein content is likely to result in a reduction in yield under some conditions at least, making such varieties commercially unacceptable. The alternative procedure has two aspects. The first is the selection of varieties giving superior strength at existing levels of protein. The regressions of flour strength on protein content shown above illustrate the practicability of this approach. The second and possibly more important programme to be adopted is the improvement of soil fertility.

Acknowledgments

The authors wish to express their thanks to Mr. L. J. Cook and Mr. A. J. Farquhar for making the South Australian data available, to Mr. I. Thomas and Mr. W. P. Cullinane for the Western Australian results, and to Mr. R. Veitch for the Queensland data. Our sincere thanks are due also to Dr. L. W. Samuel for his generous help and assistance.

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References

Biffen, R. H., and Engledow, F. L. (1926)—Wheat-Breeding Investigations at the Plant Breeding Institute, Cambridge. Ministry of Agric. and Fisheries, London.

Bissett, W. J. and Andrew, C. S. (1953)—The Effect of Nitrogen on the Yield, Nitrogen Content, and Baking Quality of Wheat grown on the Darling Downs, Queensland. *J. Aust. Inst. Ag. Sci.*, **19**: 40-4.

Breakwell, E. J., and Hutton, E. M. (1939)—A Protein 'Survey' of the South Australian Wheat Belt. *J. Aust. Inst. Ag. Sci.*, **5**: 103-6.

Cook, L. J., and Farquhar, A. J. (1946)—Baking Quality of Wheat. S. Aust. Dept. Ag. Bull. 399.

Frankel, O. H. (1939)—Analytical Yield Investigations on New Zealand Wheat. *J. Ag. Sci.*, **29**: 249-61.

Lee, J. W. (1952)—Skim milk powder for use in Australian Bread. *Aust. J. Dairy Tech.*, **7**: 118-25.

Macindoe, S. L. (1951)—Economic Results of Cereal Breeding in Australia. Conference of Cereal Breeders and Geneticists, Wagga, N.S.W. (C.S.I.R.O., Melbourne.)

Millington, A. J. (1942)—M.Sc. Agric. Thesis. University of W.A. (Unpublished).

Raw, A. R. (1951)—Review of Cereal Breeding in Victoria. Conference of Cereal Breeders and Geneticists, Wagga, N.S.W., (C.S.I.R.O., Melbourne).

Reeves, J. T. (1953)—Some effects of spraying wheat with urea. *J. Aust. Inst. Ag. Sci.*, **20**: No. 1. (this issue).

Samuel, L. W. (1938)—A comparison of the wholemeal fermentation time and Farinograph test for flour quality. *J. W. Aust. Dept. Ag.*, **15**: 178-181.

Samuel, L. W. (1938)—F.A.Q. Samples of Past Seasons. *J. W. Aust. Dept. Ag.*, **15**: 34-6.

Samuel, L. W. (1945)—The Influence of Some Crop Rotations and Fertilisers on the Strength of Wheat in Western Australia. *J. W. Aust. Dept. Ag.*, **22**: 294-302.

Sims, H. J. (1953)—Some Aspects of Soil Fertility in the Cereal Areas of Victoria. *J. Aust. Inst. Ag. Sci.*, **19**: 89-98.

Thomas, I. and Millington, A. J. (1945)—Recent Developments in Australian Wheat-Breeding. *J. W. Aust. Dept. Ag.*, **22**: 277-93.

Watson, E. R. (1953)—An Investigation of Various Aspects of Flour Quality in a number of Wheat Varieties. M.Sc. (Agric.) University of Western Australia Thesis (unpublished).

Worzella, W. W. (1934)—The Inheritance of Quality in Trumbull and Michikof Varieties of Winter Wheat. *J. Ag. Res.*, **49**: 705-14.

Worzella, W. W. (1942)—Inheritance and Interrelationship of Components of Quality, Cold Resistance, and Morphological Characters in Wheat Hybrids. *J. Ag. Res.*, **65**: 501-22.

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THE DEVELOPMENT AND MULTIPLICATION OF VIRUSES

By R. J. BEST

Introduction

Viruses do not lend themselves readily to investigation by the methods normally used for studying biological units which can be seen and studied morphologically as well as physiologically and chemically. We do not know how viruses grow or even whether they grow at all in the usual sense. However, viruses do increase in number and amount in the tissues they infect and recent studies have given us a glimpse of how they might be doing this. They also interact with each other *in vivo* to produce what appear to be particles combining some of the characters of the parent types.

But first let us consider the composition of viruses. The type *virus* can be said to be tobacco mosaic virus, shown by Ivanowski in 1892 to be capable of retaining its infectivity after passing through a bacteria-proof filter. Even though Ivanowski appeared to doubt his own results they were confirmed in 1897 by Beijerinck. This same virus was the first to be isolated in a "pure" form as a complex chemical substance, a nucleoprotein. Subsequently a number of plant viruses have been obtained in a pure state and all have been shown to be nucleoproteins of high molecular weight (several million). Such bacterial and animal viruses as have been isolated are either nucleoproteins or contain nucleoprotein as a major constituent, although the larger more complex animal viruses (such as influenza and vaccinia viruses) appear to contain other substances and structures as well, and some bacterial viruses exhibit structural organization which may be above the molecular level.

Although plant viruses were the first viruses to be obtained in a "pure" state and the first to be characterized chemically, comparatively little is known about their mode of multiplication and developmental history. For this reason I propose to deal first with bacterial viruses about the development of which much more is known.

Bacterial Viruses

Most of the information on bacterial viruses has been derived from studies of T_2 and similar viruses which parasitize *Escherichia coli*.

Electron micrographs of mature infective coli phage particles reveal them to be tadpole shaped, the T_2 phage having a head width of about 80 mμ. and an overall length of about 120 mμ. The heads contain a core of deoxyribose nucleic acid (D.N.A.) enclosed in a protein shell. The virus consists of 40 per cent. D.N.A. and not less than 55 per cent. protein. Whether these two components make up the whole of the virus is still under investigation and discussion.

Infection of the cell and development of the virus

No infective virus can be found in freshly infected cells for some time after infection although serological tests indicate the presence of some antigenic components of the virus. No virus can be found by electron microscopy or infectivity tests until about half way between

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infection and lysis. From then on the amount of complete infective virus in any cell increases at a constant rate (not exponentially). The first half of the cycle of infection, when no infective virus can be demonstrated, is known as the "latent period."

If a bacterial cell is infected with two or more related virus particles which differ in two or more characters there arise *"recombinants"* which show the characters of two or more parents. From the fact that the proportion of recombinants of any particular type is the same when they can first be detected (near the end of the latent period) and at lysis, it is concluded that recombination occurs after most of the replication has taken place and before maturation.

An important paper entitled, "The mechanism of genetic recombination in phage," by Visconti and Delbruck, appeared this year. Their theory explains not only the frequency distribution of recombinants but also the phenomenon known as "multiplicity reactivation." These authors consider the course of development of a bacterial virus to be divided into two stages namely:

Stage 1: *Vegative phase*, extends from 0 to 15 minutes (approx.) after infection. Virus material multiplies but is non-infective. During the last three or four minutes of this period these non-infective virus particles mate to form recombinants in which characters derived from two or more parents can occur in one virus particle.

Stage 2: *Maturation period*, extends from 15 to 30 minutes (approx.) after infection. Virus particles become infective and "complete" but do not multiply in the host cell. Infective virus increases at a constant (linear) rate. They do not mate. Recombinants do not revert to the parent type in the mother cell. After about 30 minutes the infected cell lyses and releases the virus, and this infective virus is then capable of setting up another cycle of infection.

Chemical studies by Seymour Cohen and others have revealed that 75 to 80 per cent. of the phosphorus and more than 90 per cent. of the viral nitrogen come from the medium after infection. The rate of synthesis of deoxyribo-nuclei acid is independent of the number of virus particles present (provided four or more particles are present per cell) and the D.N.A. produced is practically all accounted for in that liberated as virus on lysis. Specific amino-acid antimetabolites such as 5-methyl tryptophane can block virus formation. From these and other considerations it has been concluded that *virus constituents are synthesized by host enzymes* at a constant or linear rate from raw materials provided in the main by the medium. There is no evidence that constituents of the cell protoplasm are used by the virus.

The probable biochemical sequence of events corresponding to the cycle of infection described above under stages 1 and 2 is set out in Figure 1.

Plant Viruses

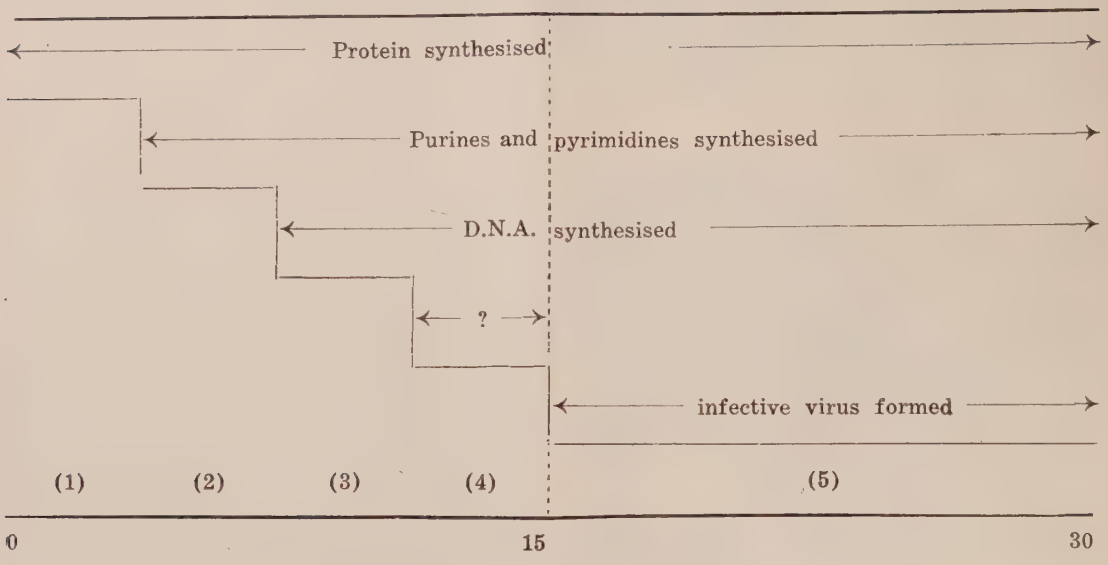
Some twelve plant viruses that have so far been obtained in a "pure" state have been found to be nucleoproteins of the ribose type. The nucleic acid content, constant for any one type, ranges from 6 per cent. to over 40 per cent. Although strains of any one virus have the same nucleic acid content they differ between themselves and their amino-acid make-up (Knight, 1947).

Pointers to mode of multiplication

Of particular interest in the present discussion is the finding of Markham and Smith that in plants infected with turnip yellow mosaic there is produced, side by side with the infective virus nucleoprotein, a non-infective phosphorus-free

Figure 1.

Diagram to illustrate the probable biochemical sequence of events in phage production by a bacterial cell (in five steps).



Approximate time Scale in minutes.

protein which is serologically, chemically and crystallographically indistinguishable from the protein part of the virus. The evidence is against this non-infectious protein being a precursor of the virus or a product of degradation. A more recent paper by Jeener and Lemoine (1953) describes a somewhat similar state of affairs for tobacco mosaic virus.

Bawden and Pirie (1953) have found nucleoprotein particles of various lengths in tobacco plants infected with tobacco mosaic. Only naturally occurring long ones were infective. Causing the short ones to become long by aggregation did not produce infective particles. Bawden and Pirie concluded that the plant provides some specific mechanisms which assemble the components in the order required for infectivity.

In an investigation of the nitrogen and phosphorus metabolism of tobacco plants infected with tobacco mosaic virus Best and Gallus (1953) found that the pattern of nitrogen: phosphorus ratios of the protein of infected plants relative to that of the healthy ones suggested that in addition to infective virus the plants contained two forms of inactive virus nucleoprotein, a non-infective pre-virus stage in the younger leaves and in the older leaves some inactivated remains of formerly infective virus.

Latent period and anti-metabolite action

Recently Bawden and Nixon have looked for and found a "latent" period in the development of infective tobacco mosaic virus in tobacco leaf.

Matthews (1953) has found that 8-azaguanine, an analogue of guanine, will inhibit multiplication of tobacco mosaic virus and has now produced evidence which supports his interpretation that this effect is caused by the replacement of the natural purine in the nucleic acid of the virus by the analogue, thus preventing multiplication.

From this and other observations it is reasonable to conclude that nucleic acid is essential for multiplication. On the other hand the protein part of the virus molecule can have most of its free

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amino groups blocked by acetylation without losing infectivity according to Miller and Stanley (1941) and to Schramm and Müller (1940).

Transformations in vivo

In our laboratories observations of the behaviour of strains of tomato spotted wilt (T.S.W.) virus have yielded data which are not satifactorily explained by existing hypotheses. For example we find that when a mild strain of T.S.W. protects plants against a severer strain inoculated subsequently, the latter still has a marked influence on the plant which can best be explained on the assumption that the severe strain multiplies in a form whose symptom expression is strikingly moderated. Table I illustrates such an effect of inoculating a severe strain B on to plants after these have been invaded systemically by strain E.

TABLE I.

Effects of strains of T.S.W. virus on yields of tomato plants.

Strain	Fresh wt. in gm. per plant		
	Fruit	Leaves and stem	Total
Healthy	60	98	158
E	42	79	121
E then B	24	63	87
B	8	41	49

Even when the severe strain is inoculated simultaneously with one or more milder strains the plants do not develop the severest symptoms in spite of the fact that the severe strain moves faster than the others. The visible effects of the various strains may be classified into "characters." The symptoms on plants inoculated with a mixture of strains A and E consist of some of the characters of A and E and other characters not normally shown by either alone. When these latter are "sub-cultured" they behave like new strains. The most severe character of A has never appeared in plants inoculated with a mixture of strains including A.

As a result of these and other observations I have developed the hypothesis that at some time early in the multiplication process the viruses, whether inoculated at different times or together, exchange character deteminants. A review of past records in the light of this hypothesis has not revealed any fact that contradicts it, on the contrary it explains many observations which were previously unexplained. Not only does it explain the behaviour of mixedly infected plants but it also provides a satisfying explanation of the protective effect of mild virus strains against severer strains and of the "synergistic" action of one strain on another. In the case of T.S.W. strains A and E inoculated together the A strain would be so modified by a re-shuffling of character determinants by the time it left the inoculated leaf that one would not expect much "pure" A to be left.

Conclusion

The latent period and the recombination of characters have been demonstrated by Burnet, Sanders, and others to apply to animal viruses also. While there is no reason to believe that all kinds of viruses will necessarily follow the same line of development in their hosts it seems likely that the basic processes involved in the latent period and during recombination are common to plant, animal and bacterial viruses.

The recent observation by Hershey and Chase that the protein shell of the infecting phage particle stays outside the infected bacterial cell while nucleic acid enters and actually initiates the production of virus even when the protein shell is removed, is strong confirmatory evidence for a view that has been growing amongst virologists that the ultimate genetic unit

responsible for replication may be the nucleic acid itself.

References

Bawden, F. C. and Pirie, N. W. (1953)—Society for General Microbiology, Symposium No. 2, Nature of virus multiplication. Camb. Univ. Press.

Best, R. J. (1953)—*Aust. J. Sci.*, **16**: 5.

Best, R. J. and Gallus, H. P. C. (1953)—*Nature*, **172**: 347.

Cohen, S. (1951)—*Fed. Proc.*, **10**: 585.

Hershey and Chase, (1953)—*Nature*, **172**: 105.

Jeener, R. and Lemoine, P. (1953)—*Nature*, **171**: 935.

Knight, C. A. (1947)—*J. Biol. Chem.*, **171**: 297.

Matthews, R. E. F. (1953)—*Nature* **171**: 1065.

Miller, G. L. and Stanley, W. M. (1941)—*J. Biol. Chem.*, **141**: 965.

Schramm, G. and Muller, H. (1940) — *Zeit. Physiol. Chem.*, **266**: 43.

Visconti, N., and Delbruck, M. (1953)—*Genetics*, **38**: 5.

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BOOK REVIEW

ECONOMICS OF AGRICULTURAL PRODUCTION AND RESOURCE USE

By EARL O. HEADY

(*Prentice Hall Inc., New York* 1952. *Pp. viii* + 850. $13).

The number of textbooks dealing with "fundamental principles and relationships and applying these to agricultural data" are few, and limited in either breadth, or depth, or in both.

This book, lacking in neither of these qualities, may be regarded as the first satisfactory single text for the researcher, teacher, and graduate student of Agricultural Economics.

The work is divided into four parts. As the author presumes the reader already has a background of agricultural economics, Part I, deals only briefly with the scope and nature of production economics.

The second part, "Planning Under Perfect Knowledge," is a "static" analysis of "production and resource use with emphasis on the individual farm and the farm household."

Part III, still with the focus on the individual farm, introduces risk and uncertainty into the analysis.

As the title, "Aggregate Aspects of Production," of Part IV indicates, attention is shifted to agriculture as an industry.

For the teacher, a merit of the book is the way in which agricultural data have been so smoothly grafted on to "contour-line" analyses with which the student of economics is now expected to be familiar. The approach throughout is largely in terms of "advanced arithmetic," but not too advanced for the non-mathematician.

An outstanding feature of the book is the absorption of modern economic theory into the analysis. Students familiar with modern welfare theory and with the implications of behaviour studies, of Katona for instance, will find these nicely integrated into the work.

Another feature is that the researcher will find it provides not only a sound base upon which to ground his own hypotheses but also, helpful in suggesting questions which appear capable of shedding light and yielding fruit.

At every opportunity the author points out the implications of his analyses for agricultural advisers and extension programmes. This is particularly valuable for Australia, where the Agricultural Economics and Farm Management approach in University course-work in Agriculture, and in agricultural extension, has not yet been adopted to nearly the same extent as in America, New Zealand and England. Further, in an attempt to improve efficiency in agriculture as a part remedy for an insufficiency of foreign exchange, the Commonwealth is making substantial grants to the states for extension. For helpful suggestions in this connection the analyses of causes of inefficiency and of firm-household inter-relationships, are most appropriate.

Unfortunately, many agricultural economists so called, are either agriculturalists with a smattering of economics, or economists with a smattering of agriculture. Heady is obviously an economist and an agriculturalist, and his book is an almost exciting addition to the library of the agricultural economist.

HENRY P. SCHAPPER.

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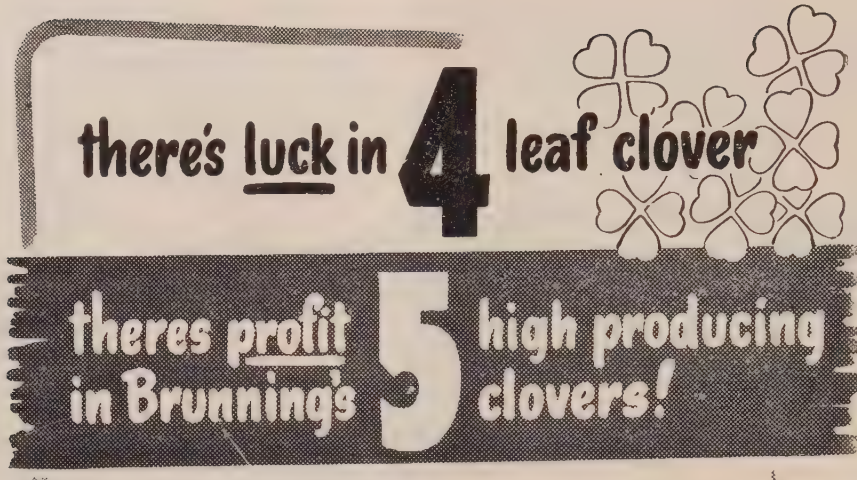

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TECHNICAL PAPERS

SOME EFFECTS OF SPRAYING WHEAT WITH UREA

By J. T. REEVES

Summary

Synthetic urea, a fertiliser containing 46 per cent. nitrogen was sprayed on to growing wheat plants in late winter and early spring. Although the yields were increased, the most significant improvement occurred in the baking quality of the grain. The percentage of mottled grain in a translucent grained variety was also decreased.

The widespread use of boom and aerial spraying for the control of weeds appear to be means by which urea can be applied, if necessary, already mixed with the insecticide or fungicide. Whether this method of applying nitrogen is an economic possibility on a large scale has not yet been demonstrated.

Introduction

In South Australia, Cornish has shown that once the deficiency in phosphorus has been overcome, usually a shortage of nitrogen in the soil then becomes the limiting factor to increased crop yields. The classical example of a decrease in crop yields followed by an increase when a legume was introduced into the rotation, is the analysis by Cornish of wheat yields on a property near Saddleworth. In this State, Shier and Cullinane also showed the value of a legume in increasing the yield and the baking quality of the flour as well. However, in many areas of the wheatbelt, particularly in the drier regions, suitable legumes have not been found and some method of applying nitrogenous fertiliser may be an economic and effective way of overcoming a low nitrogen status in the soil.

Finney, in the United States of America, obtained significant increases in wheat yields by spraying crops with urea during a period extending from seven weeks before flowering to 32 days after flowering. He used concentrations varying from approximately 8 lb. to 40 lb. nitrogen per acre and these concentrations were applied usually as single sprays, but also in one treatment with 15 different sprayings extending over a period of 32 days. In general, the greatest increases in yields were obtained when spraying was carried out from 7 weeks before flowering to just before flowering. The greatest increases in protein content occurred when the spray was applied at flowering, i.e., later than for maximum grain yield increases.

Following these investigations, three trials were laid down on the Wongan Hills Research Station in 1952 and 1953. The soil type, Wongan sandy loam, is of low inherent fertility, and on the sites selected, clover had never been established.

Procedure and Results

Trial 1 (1952)

The plot size was 100 square links with four replications of each treatment. The urea was made up into solutions and applied at the rate of 100 gallons per acre. The concentrations expressed as pure nitrogen were 0, 20, 40, and 80 lbs. per acre. These were applied as follows:—

(a) at full strengths five weeks before earing (8/8/52);
(b) at full strengths at first ears (12/9/52);
(c) one third strengths at three different times—
  (i) five weeks before earing (8/8/52);
  (ii) first ears (12/9/52);
  (iii) flowering (26/9/52).

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TABLE I

Effects of Spraying a Wheat Variety with Urea.

Nitrogen lb/ac.	Grain Yields bus./ac.	Mottling %	Transformed Mottling %	Dry Gluten %
Nil	Av.	47.4	(43.5)	9.75
10	16.62	37.9	(38.0)	10.01
20		34.5	(36.0)	10.36
40	Av.	19.9	(26.5)	11.38
80	18.92	11.2	(19.6)	11.92
Minimum differences for significance— 5%	1.73	—	(8.9)	0.98
1%	n.s	—	(12.9)	1.38

Figures in brackets are transformed values for the significance test.

The wheat variety used in this trial was M.112, a fixed crossbred derived from a cross between Eureka 2 and the stem rust resistant crossbred M.61. The grain of M.112 is normally hard and translucent and produces premium quality flour. Mottled grain develops under conditions of low soil fertility, such grain producing a flour of inferior baking strength.

The yields of grain, also the mottling and dry gluten percentages are shown in Table I. This table averages the results of the times of application as the different times were not significant and are not shown separately.

Grain Yields

The 20 lb. rate of spray did not give an increase in yield but in this treatment the presence of root-rotting diseases including take-all (*Ophiobolus graminis* Sacc.) may have been responsible for the yield depression. Because of this, the 0, 10 and 20 lb. rates of nitrogen had to be averaged and compared with the average yield from the two highest rates.

The comparison between the three lowest and the two highest rates was significant at the 5 per cent. level, the regression coefficient of yield on spray being 0.032 or approximately one bushel per acre for each 30 lb. increment in nitrogen.

Grain Mottling

The variability observed made it necessary for an angular arcsin transformation (arcsin $\sqrt{p}$) to be used in the analysis. The regression line is graphed in Figure 1.

Dry Gluten

The increases in dry gluten content of the grain, due to spraying, were highly significant, the coefficient of regression being 0.028, i.e., 0.84 per cent. increase in dry gluten for each 30 lb. increment in nitrogen.

At the highest rate of spray, the gluten percentage was still increasing at a fairly constant rate (see Figure 2 for the regression line). Therefore, still higher rates may possibly have further increased the quantity of gluten in the grain. However, on plots sprayed with the 80 lb. rate in one application, some blackening of the leaf tips was observed.

Trial 2 (1952).

To ascertain if varieties responded differently, four varieties M.112, Eureka 2, Javelin 48 and Gluclub were sprayed at first ears with the 40 lb. rate of nitrogen per acre. First ears in this section was 26th September, all varieties earing at approximately the same time. Plot size was 100 square links, with 5 replications.

TABLE II.
Effects of Spraying Different Wheat Varieties.

Variety	% Dry Gluten	Increase in D.G. %	% Protein (N × 5.83)	Pelshenke time	% Increase in Pelshenke time
M.112 not sprayed	8.28		9.73	136	
M.112 sprayed	9.51	1.23	10.80	144	5.9
Eureka 2 not sprayed	7.44		9.13	42	
Eureka 2 sprayed	8.98	1.54	9.98	59	40.5
Javelin 48 not sprayed	6.45		8.22	53	
Javelin 48 sprayed	8.40	1.95	9.79	75	41.5
Gluclub not sprayed	6.11		7.76	24	
Gluclub sprayed	8.20	2.09	9.42	28	16.7
Minimum differences for significance.— 5%	0.49		0.47	7	
1%	0.69		0.66	9	
0.1%	0.99		0.94	14	

Note: The significance levels refer to comparisons between "not sprayed" and "sprayed" sections of each variety.

Each plot was sub-divided, half was sprayed, and the other half was left as the control. Responses to the spraying are shown in Table II.

Gluten and Protein Contents

The spraying significantly increased both the dry gluten and protein contents of all four varieties. With gluten, the greatest increase occurred in Gluclub, the variety with the lowest inherent content and the smallest increase occurred in M.112, the variety with the highest inherent gluten content. These differences were not statistically significant, but suggest that responses due to applications of nitrogen are greatest in varieties with low gluten contents.

The 1953 *Trial*

This trial was laid down to test the relative efficiencies of urea sown with the grain (13th May) and sprayed on to the growing plants (6th August), about five weeks before earing.

The plot size was 100 square links with 5 replications and the variety used was Charter. The yields and protein content of Charter are set out in Table III.

The differences in 1,000 kernel weights are not significant; however, the indication is that the ground application has decreased the weights, while the spraying has increased them.

The ground applications gave the highest yields but the differences were not significant, conversely spraying gave the highest protein contents but in this case the increases over the ground applications were statistically significant.

Discussion

The maximum increases in both yield per acre and protein content of the grain were obtained by a single spraying applied five weeks before earing (seven weeks before flowering). However, the differences due to the different times of application were not significant and are

TABLE III.

Ground Versus Spray Treatments.

Nitrogen lb./ac.	Grain Yields bus./ac.	% Protein (Nx 5.83)	1,000 Grain Weight (Grams)
Nil	25.23	10.22	39.44
20 on ground	28.52	10.40	39.36
20 sprayed	25.74	11.18	39.80
80 on ground	32.22	11.21	38.34
80 sprayed	31.11	12.66	40.10
Minimum differences for signifiance.— 5%	5.04	0.48	n.s.
1%	n.s.	0.66	n.s.

therefore not shown separately in Table I (Trial 1).

The decreases in mottling with increases in the amount of nitrogen sprayed on to the plants indicate that a shortage of nitrogen is an important cause of mottled grain, also, as mottling decreased, the gluten content of the grain increased. A similar relationship between mottling and protein content was found by Breakwell and Hutton in 1939. More recently Bissett and Andrew showed that the nitrogen content of the grain, baking quality of the flour and mottling in the variety Puora were closely correlated. The relationship between dry gluten and protein contents of the varieties tested in Trial 2, is graphed in Figure 3.

With respect to Pelshenke times, three of the varieties in Trial 2 improved significantly on being sprayed, but the fourth variety, Gluclub, did not improve its Pelshenke time significantly. It seems

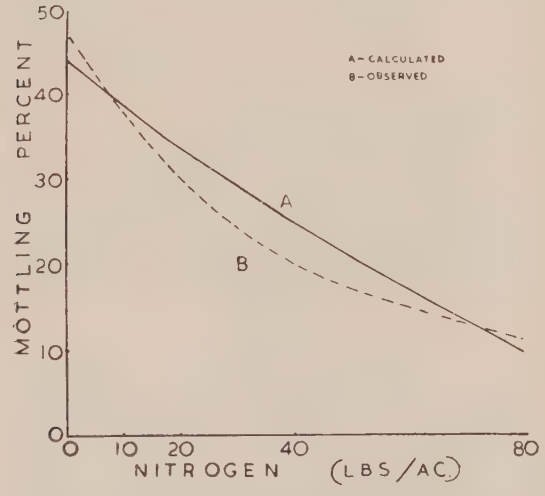

Figure 1.

The decrease in the percentage of mottled grain after spraying. In arcsin transformation the regression equation is $Y = 32.6997 - .295348\ (x - 30)$.

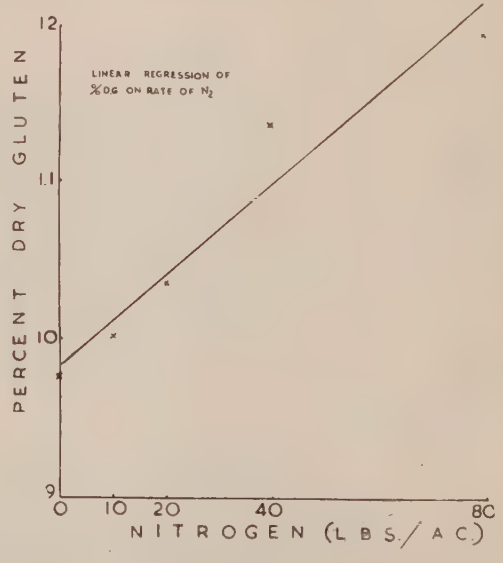

Figure 2.

The increase in dry gluten content due to the different rates of spray. $Y = 9.8345 + .028323x$.

likely that increases in the amount of nitrogen absorbed by Gluclub results in an increased quantity of gluten (and protein) in the grain without an actual increase in the baking quality of the flour. Gluyas Early, a parent of Gluclub also behaves in a similar fashion (Millington, private communication).

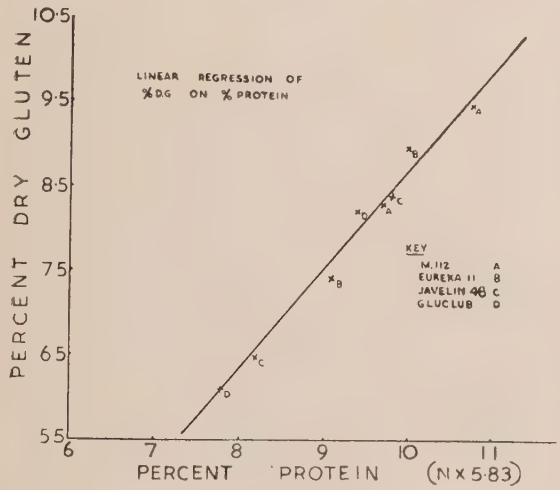

Figure 3.
Illustrating the relationship between dry gluten and protein content. The regression equation for the four wheat varieties in Trial 2 is $Y = 7.928205 + 1.156200\ (x - 9.351282)$.

Conclusion

The results of two years' trials suggest that spraying is an effective method of applying urea to a wheat crop. When this spraying is carried out some weeks prior to earing, maximum increases in yields can be expected, although for greatest improvement in the baking quality of the grain spraying can be carried out at a later stage.

Spraying is more effective than ground applications, particularly in respect to the protein content of the grain.

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References

Bissett, W. J., and Andrews, C. S. (1953)—The effect of nitrogen on yield, nitrogen content and baking quality of wheat grown on the Darling Downs, Queensland. *J. Aust. Inst. Ag. Sci.* **19**: 40-44.

Breakwell, E. J., and Hutton, E. M. (1939)—South Australian grain studies. *J. S. Aust. Dept. Ag.* **42**: 683-697.

Cornish, E. A. (1949)—Yield trends in the wheatbelt of South Australia during 1896-1941. *J. Sci. Res.* Ser B. **2**: 83-137.

Shier, F. L., and Cullinane, W. P. (1948)—The influence of rotation on the yield and flour strength of wheat. J. W. Aust. Dept. Ag. **25**: 351-361.

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TECHNICAL NOTES

A NOTE ON THE AVAILABLE MOISTURE RANGE OF SOME NORTHERN AUSTRALIAN SOILS

Agricultural development on the limestone red soils of the Katherine area of the Northern Territory has presented certain difficulties which seem to be related to the physical properties of the soils under investigation. The most important factor has been the narrow range of available soil moisture which has resulted in the appearance and development of symptoms of water stress in plants after only short periods of rainless weather. The soil contains 55-65 per cent. clay on a mechanical analysis basis; but despite this high clay content only about 6 per cent. moisture (or 1.0 in. of water per ft. of depth) is held between field capacity and the permanent wilting percentage.

Methods and Results

An x-ray analysis for the clay fraction of the same soil type collected from an adjacent locality showed that the fraction was composed of kaolinite, 65 per cent.; illite, 20 per cent.; and free ferric oxide, 15 per cent. (J. W. Holmes, personal communication). The large proportion of kaolinite, with its characteristic hydration properties, appears to be directly related to the narrow moisture range.

Very few x-ray analyses are available for northern Australian soils, but some evidence on the constitution of the clay fraction can be deduced from figures for the base exchange capacity of the clays. Grim (1942) has found the following ranges of base exchange capacity for the various pure clay minerals:

Kaolinite	3-15 m—equiv./100 g. clay
Illite	20-40 m—equiv./100 g. clay
Montmorillonite	60-100 m—equiv./100 g. clay

The clay fraction of most soils is usually composed of two or more clay minerals. Therefore a known base exchange capacity does not necessarily give direct evidence of the nature of the clay fraction although if the value is low it might reasonably be assumed that kaolinite or kaolinite type minerals must be predominant. Chemical analyses, including base exchange information were available for a number of soils from the Katherine-Darwin region of northern Australia (G. A. Stewart, personal communication). These were examined in the light of this assumption to gain some indication of the possible extent of soils containing appreciable quantities of kaolinite and therefore likely to have poor water storage capacity.

From the analyses, base exchange capacities of the clay fractions have been computed. They are listed in Table I below. All samples are from depths between 8 and 36 in. so that they represent parts of the profile where water storage is of greatest significance to agricultural plants.

The sample in the first column at the left of the table is from the soil type already discussed. This soil has a base exchange capacity of 18.5 m–equiv. All but one of the remaining samples have base exchange capacities varying from 11.5 to 22.2 m–equiv. and can be assumed to have a high proportion of koalinite in the clay fraction. The remaining sample, from a levee soil of much more recent origin than the others, has a value of 38.2 m–equiv.

Factors of importance in determining the constitution of the clay fraction of

Table I.

Base exchange capacity of the clay fraction of some northern Australian soils.

Locality	Katherine	NNW. of Daly River Police Station	W. of Daly River Police Station	Near Darwin	River levee near Katherine	S. of Douglas River	Near Adelaide River Township	N. of Douglas River
Annual Rainfall (in.)	35	55	50	60	35	40	50	50
Base Exchange capacity (m.e. per 100 g. clay)	18.5	20.8	16.7	15.9	38.2	22.2	20.5	11.5

soils are the inherent base status of the parent material, the leaching potential of the environment, and the age of the land surface. A preponderance of kaolinite type minerals is usually associated either with soils derived from acid rocks of low inherent base status, or with conditions of rapid or prolonged leaching. Most of the samples listed in Table I are from soils in which one or more of these conditions apply. The higher exchange capacity of the levee soil, which is of more recent origin, is of interest. The effect of increasing rainfall is not readily apparent in this region where even the lowest rainfall represents fairly strong leaching conditions, because it is concentrated during a short wet season. Over larger areas where greater rainfall extremes occur, effects due to different rates of leaching may possibly appear.

Conclusions

If low base exchange capacity is related to environmental conditions and is evidence for a narrow range of available moisture in soils, this characteristic may be widespread through much of northern Australia where environmental conditions similar to those in the Katherine-Darwin region exist. Such a feature may mean that much more careful consideration than would otherwise be necessary, may be required in the development of suitable agricultural practices and in the choice of agricultural plants. This is particularly true for northern Australia because of the character of the rainfall which, although reliable in its total amount from year to year, is very intermittent in nature during any one season. Groups of several consecutive rainy days are often interspersed by periods of dry weather of a fortnight or so in length, and symptoms of water stress in crop plants may appear during these dry periods if little water is available for plant growth in the root zone of the soil.

References

Grim, R. E. (1942)—Modern concepts of clay materials. *J. Geol.*, **40**: 225-275.

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THE EFFECT OF ULTRA-VIOLET IRRADIATION ON THE DEVELOPMENT OF BROWN ROT IN STONE FRUITS AFTER HARVEST

The use of Ultra-violet light for controlling mould in the meat industry and its reported effectiveness for rapidly killing fungi in culture inspired a small scale test to check the value of the treatment for controlling brown rot (Sclerotinia fructicola) of stone fruits.

Twelve samples, each of 50 fruits, were picked at a firm ripe stage from two apricot trees. The ten treated samples were inoculated by spraying with a spore suspension prepared from field infected cherries and allowed to dry overnight.

The appropriate samples were then exposed to ultra-violet light on wire netting trays placed midway between two ultra-violet lamps, one of which was 24 in. vertically above the other. After treatment the fruit was incubated at about 65°F. for 5 days at high humidity. The X^2 test gave the results shown in Table I.

Significant reduction in brown rot was obtained by 15 mins. irradiation of Tree 1 fruit and by 30 mins. with fruit from Tree 2.

Slight damage occurred on fruit subjected to 30 minutes' exposure and noticeable darkening occurred on one side of fruit irradiated for 60 minutes.

TABLE I.

Numbers of Brown Rot Infected Fruit in Random Samples of 50.

	Tree 1		Tree 2	
	No. Infected	Probability that U.V. has no effect	No. Infected	Probability that U.V. has no effect
Inoculated.				
Irradiated 0 mins.	35		25	
1 min.	29	$0.1 < P < 0.2$	24	$0.8 < P < 0.9$
15	16	$P < 0.001$	17	$0.1 < P < 0.2$
30	17	$P < 0.001$	11	$0.001 < P < .01$
60	10	$P < 0.001$	7	$P < .001$
Uninoculated.				
Not irradiated	0		0	

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THE OCCURRENCE OF "GENETIC LEAF WITHERING" IN PLANTS OF *PHALARIS TUBEROSA* X *PHALARIS MINOR*

In a programme to develop allopolyploids from F_1 hybrids between perennial and annual *Phalaris* species, two early strains of *P. tuberosa* (C.P.I.15311 and C.P.I.15590) and three strains of *P. caerulescens* (C.P.I.14146, C.P.I.14416 and C.P.I.14423) were crossed with the local *P. minor* as the male parent. Five panicles of each of the perennial female parents were pollinated with *P. minor*. The numbers of seedlings raised from the interspecific crosses and the percentages of plants with "genetic leaf withering" are given in table I.

The results given in the table indicate that the seed set may be governed by the strain of the female parent. The point of main interest is the relatively high percentage of the *P. tuberosa* x *P. minor* plants which developed brown and withered leaves. None of the F_1 plants of *P. caerulescens* x *P. minor* developed these symptoms. Figures 1 and 2 show the difference between a normal *P. tuberosa* x *P. minor* plant and one with leaf withering.

This defect in *P. tuberosa* x *P. minor* plants appeared to be due to gene inter-

Table I.

Numbers of Seedlings Raised from the Inter-specific Crosses and Percentages of Plants With Genetic Leaf Withering.

Female parent	Male parent	No. of F_1 seedlings	% plants with leaf withering
P. tuberosa C.P.I.15311	*P. minor* local	90	52.2
„ „ C.P.I.15590	„ „ „	28	71.4
P. caerulescens C.P.I.14146	„ „ „	3	0.0
„ „ C.P.I.14146	*P. minor* C.P.I.13900	9	0.0
„ „ C.P.I.14416	*P. minor* local	18	0.0
„ „ C.P.I.14423	„ „ „	151	0.0

Figure 1.
Normal F_1 plant from P. tuberosa x P. minor.

Figure 2.
F_1 plant with "genetic withering" from P. tuberosa x P. minor.

action and to have some similarities to the inherited "firing" of wheat described by McMillan (1936). The affected plants were free from fungus, and as several applications of a complete nutrient were made during growth, the defect was not due to nutrient deficiency. The latest results have indicated that genetic leaf withering occurs in a low percentage of the allopolyploid progeny resulting from the colchicine treatment of affected F_1 plants.

References

McMillan, J. R. A. (1936)—*J.C.S.I.R.*, 9: 283-294.

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SUPPRESSION OF ROOTING OF TOBACCO CUTTINGS BY YELLOW DWARF VIRUS

Grafting and insect vectors have been used for transmission of tobacco yellow dwarf virus but vegetative propagation appeared to offer a quicker and more reliable method for increasing the number of infected plants. Accordingly, stems of diseased and healthy plants grown in the greenhouse were cut into segments 6-7 cm. long to determine rooting behaviour and bud growth. The segments were obtained both with and without leaves. The base of alternate segments from each stem was dusted with talc powder containing 0.4 per cent. of indolebutyric acid. Cuttings were embedded for about two-thirds of their length in vermiculite in 6 in. flower pots which were placed in a propagation chamber maintained at a high humidity. Vermiculite is an inert material which has a high moisture holding capacity, and is readily penetrated by roots. The air temperature was approximately 18°C. After 28 days the cuttings were removed, rated for roots and top growth and then re-potted in soil.

Results

A total of 561 cuttings was taken from 32 yellow dwarf infected tobacco plants and 151 cuttings from 8 healthy plants. Approximately half of each lot were treated with indolebutyric acid.

It was found that the most important single factor influencing rooting was presence or absence of leaves. Leafless cuttings, whether healthy or virus infected, did not root at all or produced very few roots. Cuttings from healthy plants formed more and better roots than those from diseased plants while cuttings from old plants did not root as well as those from young plants. The major effect of virus infection was a reduction of approximately 50 per cent. in the number of rooted cuttings.

Treatment with indolebutyric acid did not increase the percentage of rooted cuttings either in healthy or diseased material, but there was an increase in the average number of roots and in their vigour. This effect was most obvious in leafy cuttings taken from healthy plants, and under the conditions of the experiment, indolebutyric acid appeared to act only in conjunction with other factors supplied by the leaves. These results are shown in Table I.

Discussion

Many hypotheses for the existence of different substances and factors in the leaves and for their action in root formation have been recorded (Verleyen, 1948). Overbeek (1946) concluded that the main

TABLE I.

Rooting Responses of Diseased and Healthy Tobacco Cuttings.

	DISEASED CUTTINGS				HEALTHY CUTTINGS			
	Without leaves		With leaves		Without leaves		With leaves	
	Treated *	Untreated	Treated *	Untreated	Treated *	Untreated	Treated *	Untreated
Number of cuttings	148	165	114	134	15	18	48	70
Percentage of cuttings rooted	2	4	37	46	0	0	79	83

*Indolebutyric Acid.

function of leaves in the process of root initiation is to supply the cuttings with sugars and nitrogen. Schrader (1924) found that if the soluble nitrogen is low in plants high in carbohydrate, root growth is correspondingly reduced and shoot growth practically inhibited. On the other hand, if the supply of carbohydrates is low as with very succulent tissue, no growth of either roots or tops will result even though soluble nitrogen is present. Penman (1941) states that "leaves from yellow dwarf plants are markedly lower in contents of nitrogen and of silicia-free ash, and of all ash constituents determined, than are the leaves from healthy plants".

Results obtained in this work show the necessity for the presence of leaves for rooting of tobacco cuttings, but even when leaves were present the number of rooted cuttings from yellow dwarf plants compared with healthy cuttings was considerably lower.

Of the factors supplied by leaves the major contribution appears to be carbohydrate and nitrogen and evidence from field observations and examinations of cured leaf shows that yellow dwarf plants are high in carbohydrates and low in nitrogen.

This effect of the virus on plant constituents is considered to be the major factor affecting rooting of cuttings from yellow dwarf plants.

References

Overbeek, J., Gordon, S. A. and Gregory, L. E. (1946)—*Amer. J. Bot.*, 33: 100-107.

Penman, F. (1941).—*J. Dept. Ag. Vic.*, 39: 407-412.

Schrader, A. L. (1924)—*Amer. Soc. Hort. Sci. Proc.*, 21: 187-198.

Verleyen, E. J. B. (1948)—Le Bouturage et les Substances de croissance Synthetiques.

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ERGOT OF *PASPALUM DILATATUM*

From all districts in Australia where there are pastures of *Paspalum dilatatum*, ergot* has been reported. The disease is confined to the inflorescence where the fungus, *Claviceps paspali*, invades and destroys the ovaries. Evidence of infection is the exudate of honey-dew from infected florets. During this phase of its development (the sphacelial state) the fungus produces numerous conidia which are abstricted by hyphae at the surface of the invaded ovary and thence become embedded in the honey-dew. Later the ovary is replaced by a sclerotium which eventually falls to the ground. After the winter, sclerotia develop fructifications which produce ascospores. The latter cause the initial outbreak of disease, but its spread and intensification during the summer result from the dispersal of conidia.

Introduction to Australia

During the summer of 1935-36 ergot of *Paspalum dilatatum* was recorded for the first time in Australia, and, in the course of that summer, it spread throughout the areas in the eastern States where *Paspalum dilatatum* is grown. Accounts of this disease and its effects on stock have been given by Noble (1936), Morwood (1936) and Hindmarsh and Hart (1938). Noble was unable to determine exactly when the first outbreak of the disease occurred, and suggested that the extensive occurrence of ergot in the summer of 1935-36 must have resulted from many independent centres of infection which originated from sclerotia developed in the previous season. Although that may have been the case, the ergot of *Paspalum dilatatum* can, and does, spread very quickly under warm moist conditions as is evidenced by the ready infection of new inflorescences that appear throughout the summer in south-east Queensland, and by the spread of the disease within a year to all stands of *Paspalum dilatatum* in the North Island of New Zealand (Hopkirk 1936). It seems likely that *Claviceps paspali* was introduced to Australia not long before the epiphytotic of ergot occurred in the summer of 1935-36.

Climatic Influence

Noble (1936) pointed out that sclerotia were produced in large numbers in the first year that the disease was noticed in eastern Australia. He indicated that the real significance of this large amount of potential inoculum could be gauged only in the succeeding year, and that climatological factors would probably be of paramount importance in determining the incidence of ergot in Paspalum in future years. It is now apparent that climate is not a limiting factor in the development of *Claviceps paspali* or of the ergot disease of Australia, for every summer heavy and widespread infection with *Claviceps paspali* is seen in *Paspalum dilatatum* in coastal Queensland. In New South Wales, ergot on *Paspalum dilatatum* is widespread each year, according to reports included in the Plant Disease Survey, N.S.W., for the years 1947 to 1952.

In localised areas, adverse weather conditions may prevent or greatly reduce infection of the host, the effect being on the host rather than the fungus. In south-east Queensland in 1952, drought prevailed until late summer. Under these conditions, *Paspalum dilatatum* did not thrive, and the profuse flowering customary from early summer onwards did not occur. Observations of the pastures in the Nerang Valley showed that practically no inflorescences appeared until March, but, following late summer rains, heavy flowering occurred. Widespread infection with ergot soon followed. Sources of inoculum had been established on the

* The term "ergot" may refer to either a fungus of the genus *Claviceps* or a disease of grasses caused by any species of *Claviceps*.

fringe of the area, close to the sea-coast, where infected *Paspalum dilatatum,* in a small area favoured with moisture, was found in early February. The rapid spread of the disease to grass in flower was undoubtedly due to the efficiency of insect vectors, the chief of which is *Pyrellia coerulea* (Champ and Langdon 1951).

The conditions which favour flowering in *Paspalum dilatatum* are adequate water supply and warm weather. The warm humid summer weather is also favourable to the development of ergot disease. Along the Pacific coast, the fungus and the host are widespread, and somewhere, each year, the disease is initiated. The fungus is then widely distributed by its vectors. Very little natural selection of resistant strains of *Paspalum dilatatum* can be expected, because the bulk of land under this grass is perennial pasture, maintenance of which is not dependent on natural reseeding from year to year. What are effectively the same plants occupy the pasture areas season after season. The fungus itself is not entirely dependent on the development of its ascal state each year, and it would be this part of its cycle against which one might expect climate to have its main effect. Evidence of overwintering in the sphacelial state has been obtained in Brisbane. In August, 1949, a few plants of *Paspalum dilatatum* growing in a moist sheltered situation were found in head, and heavily ergotised. A search nearby revealed a number of dead inflorescences with dried honey-dew on them. Apparently *Claviceps paspali* had persisted in the sphacelial state on a few inflorescences produced by the host during June and July. In climates milder than that of Brisbane, such as prevail in areas north of Brisbane and where Paspalum is grown, overwintering in the sphacelial state might possibly be the usual thing. We can conclude, therefore, that *Claviceps paspali* has now become permanently established in Australia, and in normal wet seasons, heavy infections of Paspalum can be expected.

References

Champ, B. R., and Langdon, R. F. N. (1951)—Unpublished report.

Hindmarsh, W. L., and Hart, L. (1938)—Veterinary Research Report for 1937, N.S.W. Dept. of Ag., pp. 78-88.

Hopkirk, C. S. M. (1936)—*New Zealand J. of Ag.,* **53**: 105-108.

Morwood, R. B. (1936)—*Q'ld. Ag. J.*, **44**: 146-147.

Noble, R. J. (1936)—*J. Aust. Inst. Ag. Sci.*, **2**: 76-78.

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A NOTE OF AN EFFECT OF LIME ON THE ESTABLISHMENT OF SUBTERRANEAN CLOVER

During 1943 some investigations were undertaken on pasture establishment at the McGarvie-Smith Animal Husbandry Farm, Badgery's Creek, New South Wales. For various reasons these were generally abortive, but the recent work of the effect of lime and molybdenum on the growth of subterranean clover (Rossiter 1952) suggests that some of the results obtained may be of more general interest.

The treatments were designed to study the effect of various dressings and forms of lime. It was anticipated that heavy liming would have an effect on the rate at which the soil absorbed water, or on the soil structure. Since a beneficial effect of liming on clover growth might be due to these physical changes as well as to direct chemical effects, a gypsum treatment was included, which would have little if any effect on the pH of the soil. A dolomite treatment was also included since magnesium deficiency had been reported on similar soils.

The plots were laid down in March, 1943, on arable land that was to be sown with oats. Subterranean clover, with $1\frac{1}{2}$ cwts. of superphosphate was subsequently drilled through the oat crop.

The treatments consisted of dressings of ground limestone at rates of $\frac{1}{2}$, 1, 2 and 4 tons $CaCO_3$ per acre; shell lime (largely calcium hydroxide) at rates equivalent to 1, 2 and 4 tons of $CaCO_3$ per acre; gypsum at a rate equivalent to 1 ton $CaCO_3$ per acre; dolomite at the rate of 1 ton per acre, and a control. Each plot was 1/40th acre, and each treatment replicated four times, the plots being distributed at random.

Plot boundaries were very obvious when the oats were harvested but the effect on clover establishment was measured the following year by counting the young clover plants on a series of line traverses of each plot shortly after the seeds had germinated, in June, 1944. The results are given in table I.

These figures embrace the effect not only on the growth of the clover, but also on the quantity of seed produced, since the original seeding rate was constant over all the plots. The increased number of seedlings with the heavier dressings is very marked, and by measuring the effect in this way it was possible to differentiate between the treatments more readily than on the first season's growth.

The result obtained appeared to be at least partly due to the improved physical condition, for the gypsum treatment, which had no effect on the pH of the soil, resulted in almost an 8-fold increase in the seedling population over the control. Moreover, 1 ton of dolomite or 4 tons (equivalent) of shell lime both raised the pH of the soil as high or higher than 4 tons of carbonate of lime but the seedling count was significantly higher with the carbonate of lime. This result is probably due to the even distribution of the carbonate of lime, for the dressing was much heavier than the dolomite, and more easily spread than the shell lime.

An attempt was made to obtain a measure of the effects of the treatment, both by measuring the infiltration rate and the pore size distribution (Leamer and Shaw, 1941), but the results were disappointing. Although it was obvious on inspection that the lime and gypsum treatments had had a marked effect on the crumb structure of the soil; it was, for example, much easier to drive the infiltration ring into the soil on these plots than on the control plots, the differences between the treatments in the infiltration rate, or in the pore space evacuated by tensions lower than pF 1.6, were not significant.

TABLE I.

Frequency of clover seedlings on plots receiving various dressings of lime.

Treatment	pH	Relative number of clover plants per plot
Ground Limestone 4 tons/acre	6.10	823
Ground Limestone 2 tons/acre	5.85	620
Ground Limestone 1 ton/acre	5.77	231
Ground Limestone ½ ton/acre	5.40	325
Control	5.28	43
Shell Lime equivalent to 4 tons/acre $CaCO_3$	6.67	687
Shell Lime equivalent to 2 tons/acre $CaCO_3$	5.92	447
Shell Lime equivalent to 1 ton/acre $CaCO_3$	5.80	337
Gypsum equivalent to 1 ton/acre	5.30	314
Dolomite at 1 ton/acre	6.12	465

(Figures are from mean of four replicates.)

The lack of significance may have been due to the shallow depth to which the effect occurred. Since both the infiltration rings and the cones for pore space determination penetrated 3 in. deep below the surface of the soil, these measurements could well have been too crude to allow the effect on structure to be demonstrated.

The effect on structure was only fleeting, for although the effect of treatment on pH could still be seen four years later, there were no apparent differences in surface structure, nor in the growth of clover on any of the treated plots.

Acknowledgments

It is desired to acknowledge the assistance of former students E. J. Waring, T. N. Stack, R. B. Jones, E. L. Greacen and K. Spencer in the work of laying out the plots and making the subsequent measurements, and the constant co-operation of Mr. H. J. Geddes.

References

Rossiter, R. C. (1952)—*Aust. J. Ag. Res.*, 3: 244.

Leamer, R. W., and Shaw, B. (1941)—*J. Amer. Soc. Agron.*, 33: 1003.

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A NOTE ON THE TRANSMISSION OF POTATO VIRUS X IN THE FIELD

Potato virus X has been generally assumed, since the work of Loughnane and Murphy (1938), to have no insect vector and to be spread principally by plant to plant contact. Some of this mechanical transmission has been shown by Roberts (1948) to occur underground, by root contact. The note by K. M. Smith (1937) that flower-inhabiting thrips may play some part in its transmission has been generally discounted. However, Walters (1951, 1952), by demonstrating that grasshoppers can transmit the virus by their chewing, has again drawn attention to the possibility that insects may play a part in the dissemination of virus X. This possibility is supported by results obtained at Canberra, Australian Capital Territory, which indicate that the pattern of X-infection occurring in the field is not consistent with the hypothesis of plant to plant spread by contact.

Experimental

In the 1948-49 summer a potato plot was planted to study the relative susceptibility to infection with virus X of five varieties, Up-to-Date, Snowflake, Bismark, Sebago and Katahdin. The plot was a randomized arrangement of 10 replicates of each variety. There were five rows 360 links long and 5 links apart, each variety occurring twice in each row. The unit sub-plot was a row of 11 plants, spaced 3 links apart, the centre plant, number 6, being an infector deliberately inoculated with virus X. Between each sub-plot and the next in the row was placed a plant of the X-immune seedling 41956 to prevent transmission between sub-plots. The material used to plant the plot came from elite stocks known to be absolutely free from virus X. The infector plants were mechanically inoculated with virus X, when approximately 6 inches high and were checked one month later by back inoculation to *Datura stramonium*. A further check occurred when the tubers of all plants in the plot were subsequently tested.

The tubers of each plant were harvested separately and X-infection was assessed by inoculating two tubers from each plant to *Datura stramonium* by the method of Bald and White (1942). Not all tubers of a plant may contract infection as indicated by Roberts (1948) and so some infected plants may have escaped detection when only two tubers were tested. Also *Datura stramonium* will not detect very mild strains of X. However, since error from both these sources would be spread at random it can be ignored in consideration of results presented here. Where it was found that an infected plant was separated from an infector by healthy plants, these healthy plants were retested to confirm the absence of virus X.

The plot was replanted in identical form in the 1949-50 season after plants that became infected during the 1948-49 season had been discarded and replaced by clean seed from elite stocks.

Results

Infector plants of Katahdin and Sebago failed to become infected and these two varieties are not included in the results which are summarized in Table I.

While the small numbers of infections that occurred make statistical comparisons impossible there are several points of interest that emerge:

(a) The varieties Katahdin and Sebago have a high resistance to mechanical infection. In 1948-49 when infector plants were inoculated, using abrasive and rubbing with the finger, every inoculated plant of Up-to-Date, Snowflake and Bismark but not one of the Sebago or Katahdin plants became infected. In 1949-50 infector plants of

TABLE I.

Incidence of X-infection in relation to infector plants. Number of plants infected in two seasons.

Variety	Adjacent to infector plants				Removed one or more from infector plants			
	Up-to-Date	Bismark	Snowflake	Total	Up-to-Date	Bismark	Snowflake	Total
1948-49	1	1	3	5	1	3	12	16
1949-50	0	1	1	2	1	5	7	13

these varieties were core-grafted in an attempt to ensure infection, but only one plant of Sebago became infected.

(b) The variety Snowflake appears considerably more susceptible to infection than Bismark or Up-to-Date.

(c) The distribution of infection is not what one would expect on the hypothesis that the primary mode of spread is from plant to plant by contact. Allowing for the fact that there are four times as many plants distant from as there are adjacent to infectors, approximately the same number of infections occurred on distant as on adjacent plants. Some of the distant plants were removed the maximum distance of five from the infector. Such a random distribution suggests the possibility of an active vector.

In an endeavour to obtain further evidence on this point a plot was established in 1952-53. It consisted of four rows of 85 plants, planted 6 links apart with 6 links between rows, so that there was no plant contact during the season. The bulk of the plot was planted with elite virus-free Up-to-Date but in each row the 1st, 22nd, 43rd, 64th and 85th plant was an infector plant of Brownell carrying virus X. Over these infector plants were placed large frames of open-mesh wire to prevent any human, animal or mechanical contact, and throughout the season no cultivation or other operation was permitted on the plot, the plants remaining completely untouched. The tubers of each plant were tested for virus X after harvest. One plant, four places distant from an infector, became infected. This is considered to be a genuine instance of transmission by a vector.

It would be as well if the possibility of active vector dissemination of virus X be kept in mind in the maintenance of Australian stocks of potato seed. The potentialities of the grasshopper as a vector are worthy of further investigation as these insects sometimes occur in large numbers in potato fields, especially in dry seasons. It may be of significance that they were scarce during the season of the final experiment described here.

References.

Bald, J. G., White, N. H. (1942)—Potato virus X: The average severity of strain mixtures in three varieties of potato. *J.C.S.I.R.* (Aust.) **15**: 300-306.

Loughnane, J. B., Murphy, P. A. (1938)—Dissemination of potato viruses X and F by leaf contact. *Sci. Proc. Roy. Dub. Soc.* 22 (N.S.): 1-15.

Roberts, F. M. (1948) — Experiments on the spread of potato virus X between plants in contact. *Ann. Appl. Biol.* **35**: 266-278.

Smith, K. M. (1937)—A Textbook of Plant Virus Diseases. J. & A. Churchill Ltd., London.

Walters, H. J. (1951)—Grasshopper transmission of three plant viruses. *Science* **113**: 36-37.

Walters, H. J. (1952).—Some relationships of three plant viruses to the differential grasshopper, Melanoplus differentialis (Thos.). *Phytopathology* **42**: 355-362.

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PARTIAL CHEMICAL COMPOSITION OF QUEENSLAND FLUE CURED TOBACCO LEAF

In the past two years numbers of tobacco leaves have been submitted to Queensland plant pathologists because of abnormal appearance, but leaves showing two distinct symptoms were always found to be free of pathogenic organisms. In one group the lesions ranged from mild interveinal chlorosis to curled and scorched apical margins with marked interveinal chlorosis or large necrotic areas. In several cases the only signs were interveinal necrotic areas with poorly defined edges. The second group had large, fleshy leaves with a tendency to roll downwards and pronounced buckling of the interveinal tissue. Leaves from both groups, when analysed for one or more inorganic constituents, gave values either very much higher or lower than figures quoted in the literature for normal plants. A systematic collection of leaf samples from various farms was therefore undertaken. These were analysed for one or more of the elements, nitrogen, calcium, boron, molybdenum, zinc, copper and chlorine. In several instances analysis for these elements was also undertaken on soil samples collected from the same portion of the farm as the leaf samples.

Procedure for plant samples

Entire plants carried to the laboratory with their roots still encased in damp soil, or plants in the field, were sampled for the three topmost fully developed leaves. These were air-dried until the blade had wilted and then oven-dried at 80°-90°C. Each sample averaged 12 leaves except where individual plants had been selected for investigation. The whole sample, including midrib, was then put through a stainless steel C & N mill to pass a 1 mm sieve. Sub-samples were dried at 106°C. prior to weighing.

Chemical Analysis

Chlorine was determined by the direct titration method (Piper 1950, p. 297) and in a number of cases also by an alkaline ash method (Piper 1950, p. 296). The electrometric titration method was used for soils (Piper 1950, p. 40).

Boron on plant material was done by ashing (Naftel 1939), and soils were extracted with boiling water under reflux.

Copper and molybdenum analyses on plants and soils were carried out by the Biochemical Section of the Agricultural Chemist's Laboratory using the technique of Clare *et al.* (1945) for copper, and Perrin (1946) for molybdenum.

Zinc was determined polarographically after wet ashing the leaves. No soils were analysed for zinc.

Discussion

Compared with tobacco plants in other countries [Arnold (1933), Askew (1946), Bacon (1950), Johnson (1952), McEvoy (1950), Swanback (1950)] and 'normal" plants grown in Queensland, most of these plants are high in chlorine but low in copper, zinc, boron and molybdenum (Table I).

From both soil (Table II) and plant analyses it can be inferred that boron and copper are likely to be limiting factors in at least two of the major tobacco-growing areas of Queensland. Trials to be undertaken this season should prove the correctness or otherwise of this prediction.

The low boron and/or copper values have correlated well with low values of

TABLE I.

Chemical composition of whole, fully developed tobacco leaves (all figures on moisture-free basis, 106°C.). Figures in brackets represent minimum and maximum values.

District	Nitrogen N%	Calcium Ca%	Boron B p.p.m.	Molybdenum Mo p.p.m.	Zinc Zn p.p.m.	Copper Cu p.p.m.	Chlorine Cl%
Inglewood	1.67 (1.03-2.90)		9.8 (4-15)	1.8 (0.9-2.8)	1 (1-3)	13.0 (5.6-16.8)	3.47 (1.73-6.81‡)
Inglewood* .. .. (Town Site)				1.5		11	
Maryborough .. (Tinana Ck.)							3.2
Bundaberg*		3.94 (2.26-4.96†)	17 (12†-23)				3.6 (0.79-5.4‡)
Burdekin Valley (Clare)		3.00 (1.97-3.96)	13 (8-28)				3.32 (2.50-4.45)
Chillagoe				<0.5		30 (29-31)	
Mareeba	1.56 (1.20-1.83)			<0.5	25		1.54 (1.10-2.30)

† Plants with foliar symptoms of boron deficiency.

‡ Plants with foliar symptoms of chlorine excess.

* Selected plants were used for these analyses; all others were taken at random.

Note.—For comparison see the following:—Arnold (1933) . . . chlorine; Askew (1946) . . . boron; Bacon (1950) . . . boron, copper and zinc in plants and soils; Johnson (1952) . . . molybdenum from culture solutions; McEvoy (1950) . . . chlorine; Swanback (1950) . . . calcium, zinc and boron.

TABLE II.

Chemical composition of surface soils (0-6" or 10") associated with tobacco plants analysed (Table I). Figures in brackets represent minimum and maximum values. (All figures on moisture-free basis, 106°C.).

District	Water Soluble Boron B p.p.m.	Total Molybdenum Mo p.p.m.	Total Copper Cu p.p.m.	Water Soluble Chlorine Cl p.p.m.
Inglewood	0.5	2.8 (2.7-3.0)	12.8 (11-15)	<20 (<10-70)
Inglewood .. .. .. (Town Site)	0.8 (0.4-1.6)			10 (10-10)
Maryborough .. .. (Tinana Creek)		5.0 (2.0-7.6)	0.9 (0.7-1.2)	<10 (trace-<10)
Bundaberg	0.36 (0.32-0.40)			60 (20-100)

each element in the soil for the Inglewood, Maryborough, Bundaberg and Burdekin area. In Queensland most plant copper determinations have been carried out on pasture species and the correlation between plant copper and total soil copper has been poor. Zinc and molybdenum may be expected to give some results in the Bundaberg and Mareeba-Dimbulah areas as the marked responses to the application of plant ashes in at least one case in each area seem to be due to one or both of these elements.

The majority of soils analysed contain less than 20 p.p.m. Cl to a depth of 4 feet, and although this could provide the chlorine found in the plants, it is also possible most of the chlorine comes from the irrigation water. The waters used are classed as good quality irrigation waters (total solids <6 m-equiv./l.). But in the area south of Maryborough (Tinana Creek) water containing 4.2 m-equiv./1. chlorine could more than account for the 3.2% (dry matter basis) Cl. found in the 900 lbs. of leaf as 24 acre inches/acre were applied during the growing period of this crop. There would be little loss of chlorine by leaching as the crop was grown entirely on applied water.

Summary

1. Queensland tobacco leaf, and in some cases, soils from the same area have been analysed for one or more of the elements nitrogen, calcium, boron, molybdenum, zinc, copper and chlorine.

2. Results in Table I show undesirably high chlorine values, low copper and boron figures and sometimes low zinc and molybdenum content.

3. Applications to the soil of mixtures high in potassium have been included in fertiliser trials to be conducted in the main tobacco growing districts. Observation trials with boron, molybdenum, zinc and copper have also been established.

4. In Queensland tobacco growing areas, the tobacco plant has proved to be a good indicator for low soil values of copper and boron.

5. High plant chlorine appears to be mainly derived from chlorine, added either in irrigation water or potassium chloride applied to crops rotated with tobacco rather than from the original soil chlorine.

References

Arnold, C. W. B. (1933)—*Rhodesia Agric. J.*, 30: 175.

Askew, H. O. (1946)—*N.Z.J. Sci., Tech.* (A) 28: 164.

Bacon, C. W., Leighty, W. R. and Bullock, J. F. (1950)—U.S.D.A. Tech. Bull., 1009, p. 21.

Clare, N. T., Cunningham, I. J., and Perrin, D. D. (1945)—*N.Z.J. Sci. Tech.*, (A) 26: 340-350.

Johnson, C. A., Pearson, G. A., and Stout, P. R. (1953)—*Plant and Soil*, 4: 187.

McEvoy, E. T. (1950)—*Lighter*, 20: 3.

Naftel, James A. (1939)—*Ind. Eng. Chem. Anal.* Ed., 11: 407.

Perrin, D. D. (1946)—*N.Z.J. Sci. Tech.*, (A) 27: 396-405.

Piper, C. S. (1950)—Soil and Plant Analysis, Adelaide.

Swanback, T. R. (1950)—Connecticut Agric. Expt. Stn. Bull., 535.

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INSTITUTE AFFAIRS

PRESIDENT, 1954

DR. I. F. PHIPPS

The President of the Institute for 1954 is Dr. I. F. Phipps.

Dr. Phipps was born at Picola, Victoria, and commenced his life-long association with agriculture by spending his early years on his father's property at Berrigan, N.S.W. He matriculated at Scotch College, Melbourne, in 1920 and graduated with the Bachelor Degree in Agricultural Science at Melbourne University in 1924. After graduating he was appointed to the staff of the Waite Agricultural Research Institute, University of Adelaide, as Geneticist. However, the appointment was deferred to enable him to visit U.S.A. and attend the Cornell University, where he was awarded an international Education Board Fellowship. Dr. Phipps studied under this Fellowship at Cornell for an additional two years and obtained the degree of Doctor of Philosophy in 1928.

Dr. Phipps then returned to Australia and took up his appointment at the Waite Institute, where many graduates in Agricultural Science from Adelaide University will remember him as a capable and understanding lecturer. Australia will also remember him at this time for his work on the breeding of rust and drought resistant wheats, which culminated in the development of Warigo. Between lecturing and research work, Dr. Phipps ably represented South Australia on the hockey field.

At the beginning of the last war Dr. Phipps was seconded by the University of Adelaide to the Flax Production Committee of the Commonwealth Department of Supply and Shipping to co-ordinate research work. Since the crop was almost unknown in Australia, and Britain had asked for urgent production, it is a compliment to Dr. Phipps and his co-workers that 60,000 acres of flax were grown in one year prior to the end of the war.

The end of the war saw the beginning of a new era in agricultural chemicals, and Dr. Phipps joined Imperial Chemical Industries of Australia and New Zealand. D.D.T. had been discovered early in the war and Dr. Phipps, acting as the Technical Service Officer, did much to develop the successful use of D.D.T. formulations for the control of such economically important pests as codlin moth and Oriental fruit moth. When appointed Commercial Manager, Chemical Group, in 1950, Dr. Phipps became responsible for the commercial development of many newer agricultural chemicals in the field of insecticides, weedicides, fungicides and anthelmintics.

Anyone who has worked with Dr. Phipps will not fail to have noticed the spontaneous enthusiasm coupled with levelheadedness with which he undertakes any matter he is associated with. We are fortunate indeed in having obtained a President whose well-balanced friendliness endears him to all and provokes the respect of those who may differ from his point of view. Despite his considerable pre-occupation as Technical Manager of the Biologicals Division of I.C.I., we may feel certain that his contributions to the Institute will continue to be effective and practical.

THE AUSTRALIAN MEDAL OF AGRICULTURAL SCIENCE

AWARD TO ARTHUR F. BELL

The Australian Medal of Agricultural Science for 1954 was awarded to Mr. Arthur F. Bell, Under Secretary of the Queensland Department of Agriculture and Stock. At the 21st General Meeting held at Canberra on 12th January, 1954, the President, Dr. I. F. Phipps, presented the medal to Mr. Bell.

Mr. Bell, after service with the first A.I.F., entered the Faculty of Science, University of Queensland. On graduation, he proceeded to the University of California, and the Imperial College of Science and Technology, London, for post-graduate studies. On returning to Australia, he was appointed to the Bureau of Sugar Experiment Stations, Queensland, and in 1943 became Director of that organization. In 1947 he was appointed Under Secretary, Department of Agriculture and Stock.

The whole field of Queensland's agricultural administration and research, whether it concern the C.S.I.R.O., the State Department of Agriculture and Stock, the University, or the Lands

PRESENTATION OF THE AUSTRALIAN MEDAL OF AGRICULTURAL SCIENCE.—Dr. I. F. Phipps (right) presenting the Medal to Mr. A. F. Bell (left) with Dr. Callaghan and Mr. Christian in the background.

Photograph by L. J. Dwyer, Canberra.

Department, has had the benefit of Mr. Bell's advice and leadership during the last five years. In the Department of Agriculture and Stock he has brought the administration, research and extension services to a high level of efficiency. Moreover, beyond his own department, he has served as Chairman of many committees and boards, including the Gatton Irrigation Research Station Committee, the Committee on Bulk Handling of Wheat, the Committee Enquiring into Veterinary Training in Queensland, and the Brisbane Milk Board; also he has been Deputy Chairman of the Bureau of Investigation of Land and Water Resources, and of the Sugar Experiment Stations Board. He has been a member of the Royal Commision on Pastoral Lands Settlement and of the Committee nominated by the United Kingdom Ministry of Food to advise on future activities of the Queensland-British Food Corporation.

In addition to these services to Queensland, Mr. Bell has been associated with matters of Commonwealth interest. In 1951 he was a member of the delegation appointed by the Commonwealth Government to attend the Sugar Conference in London, and he was also a member of the Commonwealth Sugar Enquiry Committee which was commissioned in 1952 to enquire into the technical and economic position of the Australian sugar industry.

At both Commonwealth and State levels Mr. Bell has been an outstanding agricultural executive and an able ambassador for Australia and the State of Queensland in matters vital to their development.

COUNCIL PROCEEDINGS

ANNUAL GENERAL MEETING

The 21st General Meeting of the Institute was held in Canberra on 11th and 12th January, 1954. The following is a summary of the resolutions carried:—

1. That the Minutes of the 20th General Meeting, as amended, be adopted and signed as a true record.

   (The amendment consisted of altering the times of commencement and finishing from 8 p.m. and 10 p.m. to 3 p.m. and 5 p.m. respectively).

2. That the Report of Council for the year 1953, as read by the Hon. General Secretary, be adopted.

3. That the report of the Hon. Editor, as presented by Dr. Phipps, be adopted and that the Meeting congratulate the Publications Committee on the way in which the Journal has developed and on its work during the year.

4. That the Financial Statement as presented by the Hon. General Treasurer be adopted, and that the statement of Journal accounts and the report of the Hon. Business Manager be referred to Council, when they are received, for examination and appropriate action.

5. That the audited Statement of the A.J.A.R. Distribution Account, as presented by the Hon. General Secretary, be adopted.

6. That the Articles of Association be amended as follows:—

   Insert after Article 45—"46 (a) Subject always to the proviso contained in Article 39 of these Articles, the Council shall have power (i) To engage and dismiss from time to time such managers, clerks, servants and agents, at such remuneration and subject to such terms and conditions as the Council shall see fit; (ii) To delegate to and impose upon any manager, clerk, servant or agent appointed pursuant to this Article all such powers and duties as the Council shall from time to time determine and to enter into any Agreement on behalf of the Institute with any such manager, clerk, servant or agent so appointed; (iii) To take such steps by way of advertisement or as the Council may see fit for the purpose of calling for applications for any appointment to be made pursuant to this Article."

   Article 46 to be renumbered 46 (b).

7. That the Institute favours the publication of a book on agriculture and offers its help to Mr. P. J. Skerman to carry out the project in accordance with his original proposal, provided the Institute is not committed to any financial obligation in regard to its publication.

8. That this meeting recommends to Council that the By-laws covering the award of the Australian Medal of Agricultural Science be amended as follows:—

   1. The A.I.A.S. shall periodically award a medal to the member of the Institute who, in the opinion of Council, has made a meritorious contribution in any field of agricultural activity.

   2, 3, 4, 5, 6, and 7. Unaltered.

   8. The complete list of nominations, with copies of supporting data, shall be forwarded to a Recommending Committee appointed by Council for the purpose of recommending the recipient of the Medal each year.

   9. The Recommending Committee.

      (a) The Recommending Committee shall consist of three financial Corporate, financial Emeritus or Honorary Life Members of the Institute who, in the opinion of Council, are of sufficient standing and experience in the profession of agricultural science to be competent to assess the merits of candidates from any field of agricultural activity.
      (b) One member of the Recommending Committee shall retire each year but shall be eligible for reappointment.
      NOTE. In the initial appointment, individual members shall be appointed for 3, 2 and 1 years respectively.
      (c) The Committee shall make its recommendation to Council and this recommendation shall reach Council not less than 4 weeks before the Annual General Meeting at which the award is to be made.
      (d) In its assessment of candidates the Committee may, at its discretion, include for consideration any candidates nominated in the previous year.

   10. Members of Branch Committees, of Council and of the Recommending Committee are requested to hold the names of candidates in strict confidence.

9. That this Meeting views with favour the establishment of a Central Secretariat and recommends to Council that it be given serious consideration. If the Council is satisfied, it is empowered to give effect to the proposal.

   If the Council decides to proceed to establish a Central Secretariat, it should take into consideration the draft outline of duties and functions, as circulated to members before this meeting, together with the following suggestions:—
   (a) The title of the executive officer be reconsidered.
   (b) Duties (iii) and (iv) be amended to read:—"(iii) To undertake special

inquiries as directed by Council and to be responsible for the preparation of fully-documented reports to assist in formulation of Institute opinion on matters under consideration. In so doing, to seek authoritative advice from members and, as appropriate, to be directed by sub-committees appointed by Council. (iv) As directed to prepare, for the consideration of Council, press or other public statements expressing the views of the Institute on issues of concern to the welfare of agriculture or to the profession of agricultural science. Such statements to be issued by the President and in his name."

10. That Council examine means of securing continuity of the service of the President to the Council, including the possibility of providing for a two-year term, and take any necessary action to achieve this end.

BRANCH NOTES

Australian Capital Territory

Mr. H. E. Dann, Senior Executive Engineer of the Snowy Mountains Authority, was the speaker at the Branch meeting on 4th November, 1953. Mr. Dann began his address by stating that the Snowy Mountains Scheme had its genesis in the last century. The present scheme was initiated in 1949.

Although the Snowy River is the main one involved in the scheme, the Murray, the Tumut, and the Murrumbidgee are also concerned. The whole river system is involved and, as it contains the snow-fed rivers of Australia, there is an assured water supply. The scheme is designed primarily to turn the waters inland for irrigation use in the Murray and Murrumbidgee valleys. The Snowy River is several thousand feet above the western rivers and will be used for the generation of hydroelectric power. The diversion of the Snowy at Jindabyne and the Eucumbene, at Adaminaby, and several subsidiary projects with their associated tunnels and power stations were outlined and illustrated diagrammatically.

A colour film was also shown illustrating the early work carried out in the area.

Mr. F. Wilson, Principal Research Officer, Division of Entomology, C.S.I.R.O., addressed the meeting of the Branch on 10th December, 1953, on the subject of Biological Control. After outlining the whole series of biological phenomena associated with parasitism, Mr. Wilson dealt with some of the more purely entomological aspects, referring to some of the more interesting work abroad as well as in Australia. Biological control is predominantly concerned with establishing, as a permanent part of the fauna, primary parasites and predators of particular alien insect pests. A high degree of control appears to require, among other things, a proper synchronization of the life cycles of host and parasite and a high level of searching capacity by the parasite population. In discussing weed control, Mr. Wilson quoted the phenomenal success of the campaign against prickly pear and demonstrated that it was no longer reasonable to question the feasibility of the biological method of weed control.

At the conclusion of the Annual General Meeting of the Institute in Canberra, a dinner organized by the A.C.T. Branch was held in the Gloucester restaurant on Tuesday, 12th January. The dinner was attended by 64 people, including visiting delegates and other members of the Institute who had arrived for the A.N.Z.A.A.S. conference. The Institute medal was presented to Mr. A. F. Bell by the newly-elected President, Dr. I. F. Phipps. Honorary Life Membership Scrolls were also presented by Dr Phipps to Professor R. D. Watt, and to representatives of the N.S.W. and Victorian Branches, who received them on behalf of Professor W. L. Waterhouse and Professor S. M. Wadham. The retiring President, Dr. A. R. Callaghan, gave his Presidential Address at the conclusion of the dinner. Dr. Callaghan's comments on the future activities of the Institute provided much food for thought.

On Monday, 18th January, the A.C.T. Branch members entertained visiting members of Section K of A.N.Z.A.A.S. at a Cocktail Party in the gymnasium at the Royal Military College, Duntroon. Approximately 250 members and guests were received by the Branch President, Mr. C. S. Christian, and Mrs. Christian, and the President of the Institute, Dr. I. F. Phipps, and Mrs. Phipps.

New South Wales

At the last ordinary meeting held on 29th October, 1953, there was considerable discussion on the proposals for the formation of a Central Secretariat in the Institute. It was considered to be a sound move provided that members were not subsequently committed to an increase in subscriptions.

The main business of the evening was an address by a visitor from Hawaii, Mr. C. F. Lennox. Mr. Lennox spoke informatively and entertainingly on "Agriculture and Agricultural Research Institutions in Hawaii and their Inter-Relationship." He commenced by describing the

topography and climate of the Hawaiian Islands. With mountains rising to 14,000 feet, almost all kinds of climate exist and there are great variations in both rainfall and temperature. Only 7½ per cent. of the land is cropped, to sugar cane, pineapples and other fruits, while 35 per cent. is given over to pasture, mainly for beef cattle. In 1951 the area under cultivation was 308,000 acres which produced sugar valued at $136m. and pineapples worth $100m. Sugar is grown on a 22 to 24 months' cycle and yields range from 4 to 15 short tons per acre. Marketing and research problems are handled co-operatively and financed by a tax on production. The sugar plantations are highly developed and, owing largely to labour difficulties in recent years, are now extensively mechanised. Herbicide sprays are widely used and have been a "lifesaver."

The pineapple industry commenced in 1903 and was booming by 1918. The area under this crop is now 75,000 acres and yields range from 25 to 45 short tons per acre. About half the crop is canned as juice and the rest as slices. The crop is grown on drier, higher land than sugar, but still on the comparatively rich porous basaltic soils, the areas being 800 to 3,000 feet above sea level, with a rainfall from 25-60 inches per annum. The cost of growing pineapples is high, about $1000 dollars per acre; pest control, fertilizing and irrigation are all expensive. The method of irrigation is unusual and extremely mechanized. Portable pipe lines and roads 120 feet apart run through the plantation, trucks with 120 feet booms connected to reeled hoses move through the crop at a speed of 1 m.p.h. and apply two inches of water.

Research plays a very important part in Hawaiian agriculture. Both the Sugar Experiment Station and the Pineapple Research Institute have a world wide reputation. A widespread extension service and research stations for other agricultural produce are supported financially by both State and Federal authorities. The biological control of insect pests has been very successful in Hawaii and has been developed mainly by the Territorial Board of Agriculture and Forestry. The Board carries out little other research and is mainly concerned with administration of various Acts covering quarantine, marketing, weed control, animal health and other matters. In Hawaii research is co-operative. State and Federal agencies and industry all play an active part. It has paid big dividends and the average income from all agricultural and pastoral lands is now as high as $90 per acre per annum.

Queensland

The October meeting was devoted to Notes and Exhibits. Mr. W. J. S. Sloan spoke of the work which will be done at the Inglewood Tobacco Experiment Station, which was recently set up by the Department of Agriculture and Stock. Mr. F. Chippendale described the soils of the area. The arable soils are mainly loams in texture, while the subsoils, although no heavier than clay loams, often show poor structure and are compacted. The supply of major plant foods is satisfactory in the main soil types, which are classed as red brown earths.

The development of the grain sorghum industry in Queensland was outlined by Dr. L. G. Miles. A wide range of varieties from various parts of the world was introduced in the mid-1930's, and of these Wheatland and Kalo are still widely grown. A plant breeding programme initiated at the Biloela Regional Experiment Station in 1941, and transferred to Kingaroy in 1948, has produced new varieties, notably Alpha, a general purpose grain variety, Coastland, an open-headed grain variety for coastal areas, and Capricorn, a dual-purpose grazing and grain variety. Recent work at Kingaroy by Mr. J. A. Kerr has produced a low-HCN, attractive grazing, type of Sweet Sudan grass, which has now reached the seed certification stage.

Mr. C. S. Andrew discussed the expression of symptoms of nutrient deficiency in the Ladino variety of white clover and plants showing deficiencies were exhibited.

Mr. A. R. Brimblecombe referred to the various insects known as armoured scales, soft scales, wax scales, mealy bugs, cochineal insects, felted coccids and ground pearls which, previously grouped as the Coccidae family, are now regarded as constituting a super-family, the Coccoidea. It is claimed that there is greater heterogeneity amongst the 2,500 to 3,000 species of this super-family than in any other group of insects. The several overseas authorities are not familiar with the whole range of Coccoid fauna in other countries and do not completely agree on the number of families and the genera to be included in them. The history of the group reveals considerable confusion and this applies particularly to Australia, since these insects have never been critically reviewed in this country. A thorough study is now in progress.

From the studies so far made it is evident that Australia has its own peculiar endemic Coccoid fauna. This is shown by the large number of endemic genera. Many of these are monotypic but it is considered that many new species are still to be discovered. The genera associated with long established endemic flora have already been shown to have evolved many species. The genus *Apiomorpha*, restricted to Eucalypt hosts, is a good example.

The Australian species have a high biotic potential, but are kept to a balance by natural agencies. When the cottony cushion scale gained access to California it threatened the citrus industry in that country until natural enemies were obtained from Australia. When South Africa and New Zealand commenced the commercial exploitation of eucalypts, the gum tree scale proved a considerable handicap until natural enemies from Australia were introduced.

Most of the pest species, and there are many of them, are foreigners and gained access to Australia in pre-quarantine days. Control work has been carried out on these pests for many

years and investigational work is still in progress on some of them. Work of this nature was explained at an earlier meeting when Mr. Manefield discussed experiments on red scale of citrus.

The November meeting was the Annual Branch Prize Meeting. Nine undergraduates in the Faculty of Agriculture, University of Queensland, submitted papers, and Mr. D. S. Teakle, Mr. O. T. Denmead and Mr. E. Jones were selected by the panel of judges to read their papers at the Branch Meeting. The prize was won by Mr. D. S. Teakle for his paper, "The Association of Fungi with the Roots of Healthy Plants." The results of Mr. Teakle's investigation of the mycoflora of roots of tomato plants of *Fusarium*-resistant and *Fusarium*-susceptible varieties were the basis of this paper.

South Australia

Some technical problems of the wine industry were described at a meeting on 10th October by Mr. J. C. M. Fornachon. He said Australia stood 14th on the list of wine producing countries, producing only 2 per cent. of the output of the leading countries, France and Algeria. South Australia produced 80 per cent. of the Australian total.

Mr. Fornachon traced the development of the industry, which had become based on the export of fortified wines to the United Kingdom. South African wines offered keen competition, and to compete favourably, the Australian industry would have to look to quality. This was dependent on the quality of the grapes themselves, the changes during the wine making process and the changes during maturation. But grape quality was the most important factor. To improve this, varieties should be tested in different districts on different soil types, and the results assessed firstly by wine quality, then by chemical analysis and yield.

The study of changes during the wine making process was limited by lack of precise knowledge of the composition of grapes. In Australia, information was lacking on even some of the major constituents such as organic acids. But the process was not haphazard, selected strains of yeast were used, temperature and pressure were controlled, and inhibitors and activators were used.

Many practices developed empirically could now be re-examined. For instance, in Europe, the growth of the mould *Botrytis cinerea* on Sauterne grapes produced evaporation and high sugar content so that fermentation could be stopped with a mild dose of SO_2. Without *Botrytis*, more SO^2 was needed and this affected palatability. There were other practices which could be used to improve quality.

Changes during maturation were also not well understood. Control of these changes was the main task of the practical oenologist, but he was handicapped by lack of precise knowledge of what was going on. This became increasingly important if an attempt was made to depart from the traditional slow maturation.

In 1934 Oenological work was begun at the Waite Institute. Policy was directed by an Oenological Research Committee and the work had been confined to four major projects—Spoilage of wine, maturation of Flor sherry, testing and selection of wine yeasts, and bacterial decomposition of organic acids. In addition a stock of information on the composition of Australian wines was being compiled.

The problems of the Australian wine industry were both general and local, and their investigation was handicapped by lack of finance, facilities and trained personnel.

At a meeting on 13th November the controversial subject of legume inoculation was discussed by Mr. J. R. Harris, microbiologist, in the C.S.I.R.O. Division of Soils. He said sub. clover could be grown economically without inoculation, but inoculation was the quickest way of increasing the population of effective *Rhizobia* where they were in short supply.

Rhizobia exist as saprophytes in the soil, without the clover host. The main factor controlling the number was the amount of plant root. In the presence of plant roots, numbers built up rapidly. Without inoculation, nodules were few and scattered, but spread up and down the root in time.

When put with the seed, the *Rhizobium* in the inoculum must be able to compete with the existing population in the soil and with the antibodies. A strain giving excellent results on its own in a sterilised soil might be useless when mixed with the general population.

Promiscuity occurred. A strain of *R. trifoliae* could live symbiotically on sub. clover and also on melitotus, while a strain of *R. meliloti* might work efficiently with sub. clover and only poorly with melilot.

A strain must be able to build up against competition from other organisms. By making two strains compete in sterile soils, it was possible to build up vigor, but the picture so obtained was likely to be different from that where a more diverse population existed.

"Recent Advances in Sheep Breeding" was the title of an address given to the Institute by Mr. P. G. Schinckel on 12th February. Formerly Senior Lecturer in Animal Husbandry at Roseworthy Agricultural College, Mr. Schinckel has now left to become Principal Research Officer at the C.S.I.R.O. Sheep Biology Laboratory, Prospect, N.S.W.

He described how oestrus in ewes was apparently stimulated by the sudden presence of rams. Thus, if vasectomised rams were added in advance of the chosen fertile sires, their presence stimulated most of the ewes to come in season. This concentrated lambing into a shorter period with obvious benefits.

Mr. Schinckel said the work at Roseworthy had largely concerned the hereditability of economic Merino traits. The work so far indicated that most of the economic factors were only weakly inherited, which meant that phenotypic selection gave a rate of improvement equal to

that obtainable by progeny testing to solve the genotypic make up of the sire. Phenotypic selection could be improved by using more accurate methods of classing.

Victoria

Dr. F. T. Wahlen, Director of the Agricultural Division of F.A.O. of the United Nations, addressed the Victorian Branch on "F.A.O.—Its Work and Its Problems" on 24th January.

F.A.O. is aimed at organizing the food supplies of all people of the world at a decent level. The idea behind F.A.O. is self-help and eventual self-sufficiency of the member nations in the production and distribution of food; already there has been a big improvement in this direction. Technical assistance is given by the more agriculturally advanced nations sending practical scientific experts to help the backward nations to solve their problems on the spot. In a great many cases, by applying the known methods of pest control, and by employing the principles of genetic breeding and improvement, the agricultural production of an area can be greatly increased. Membership is open to all nations, but assistance is only given when requested.

F.A.O. is an international organization and handles international problems such as statistics and the prevention of the spread of plant and animal diseases. It also provides fellowship and training schemes, equipment and rural credit. The cost of F.A.O. is $6,000,000 per annum, a cost which is repaid many times over. In 1953 there were 439 experts in the field giving assistance in 53 countries and territories. The Agricultural Division could handle relatively few requests for assistance. Contributions to F.A.O. in money alone are not enough, nations should make a personal effort. Dr. Wahlen made reference to Australia's close connection with F.A.O., both in its formation and its work. Australia's contribution to the organization has been far above the average in conferences, meetings and technical assistance such as the Colombo Plan. The address was followed by a lively and interesting discussion.

The garden party welcome to new graduates was held at the School of Agriculture on 27th November. In spite of inclement weather, the gathering was a success and new graduates were satisfactorily inducted into the ranks. The party was followed by a film show.

The brochure, "Agricultural Science as a Career," prepared by the Public Relations Sub-Committee of the Branch, has been printed and distributed to schools. This has been accompanied, in many cases, by talks given to classes by members of the Institute. Special editions of the brochure requested by other States have now been completed and sent to them for distribution.

Western Australia

A talk entitled "Rumen Function" was given by Messrs. R. J. Moir and M. C. Nottle on 11th November. Mr. Moir discussed carbohydrate metabolisms and dealt with the environment within the rumen and the local bacteriological studies that have been carried out under different systems of feeds and feeding. Mr. Nottle, dealing with protein metabolism, said that synthetic urea could be utilised by ruminants. Emphasis was placed on the great variability between individual animals in the utilisation of nutrients.

On 13th December, Dr. R. C. Rossiter gave an address on "Californian Pastures." This talk was illustrated by kodachrome slides taken by Dr. Rossiter during his recent trip overseas. Of great interest to the local audience was his statement that in California the use of trace elements, particularly zinc and molybdenum, with pastures had not received much attention. Dr. Rossiter showed some very good slides of the response of hill pastures in California to the sulphur contained in superphosphate.

A very successful barbecue was held on 18th December at the Animal Health and Nutrition Laboratories, Hollywood. Films were shown and refreshments provided. It is hoped to make this function an annual feature of the Branch social activities.

A general meeting was held on 22nd January to receive the Branch President's report of the Annual General Meeting of the Institute, at which Mr. H. G. Cariss had represented the Branch. Later in the evening some films were shown.

PERSONAL NOTES

Australian Capital Territory

Mr. C. I. Davern has recently joined the Genetics Section of the Division of Plant Industry, C.S.I.R.O., at Canberra, as a Research Officer, having just completed his course in Agricultural Science at Sydney University.

Mr. J. L. Lewis, of the Bureau of Agricultural Economics, Canberra, has recently returned from Harvard University after spending some eighteen months in the United States during the tenure of a Commonwealth Fund Fellowship. During his stay in the United States, Mr. Lewis paid particular attention to the study of agricultural policy and the economics of agriculture. He also spent several weeks studying the operations of the Farm Credit Agencies of the United States Department of Agriculture. While in the United States, Mr. Lewis travelled over 20,000 miles visiting Land Grant Colleges and studying Agricultural Extension Services.

Dr. J. F. Lonergan has taken up an appointment with the Division of Plant Industry, C.S.I.R.O., Canberra, after returning from three years post graduate study in the Department of Plant Nutrition, University of California, at Berkeley. His study was sponsored initially by a Hackett Research Studentship and a Fullbright Travel Grant, and was completed under a C.S.I.R.O. Studentship. The function of molybdenum in plants was the subject of his research.

New South Wales

Mr. K. P. Barley has returned from the U.S.A. and Europe and is continuing his work on soils at the C.S.I.R.O. Regional Pastoral Laboratory at Deniliquin.

Mr. E. J. Breakwell, who for the last six and a half years has been Senior Lecturer in Agronomy and Agrostology in the Faculty of Agriculture at the University of Sydney, has joined the staff of the Australian Mercantile Land and Finance Co. Ltd. as pastures adviser. Mr. Breakwell has been leader of a research team investigating the decline in pasture on the big scrub country of the Richmond River of the North coast.

Dr. H. B. Carter of the C.S.I.R.O. Wool Biology Laboratory in Sydney will be leaving for the United Kingdom at the end of April. He has accepted a position with the Agricultural Research Council in the Animal Breeding Research Organization and will be stationed at Edinburgh.

Dr. E. T. Edwards of Messrs. Houghton & Byrne Pty. Ltd. has recently returned from U.S.A. where he made a study of developments in commercial control of insect pests. He was particularly interested in soil sterilization and nematode control and it is understood that he has brought back a number of promising new insecticides. Dr. Edwards was a pioneer in Institute affairs in this State and was well known as a plant pathologist in the New South Wales Department of Agriculture and later as an agricultural journalist. He is working in his new sphere with characteristic enthusiasm.

Mr. T. R. Lawler, rice plant breeder at the Yanco Experiment Farm of the N.S.W. Department of Agriculture, has left for a period of 12 months in Italy. He obtained an Italian Government scholarship to study rice growing and breeding in that country.

Mr. A. C. Orman, Principal Agronomist (Vegetables) in the N.S.W. Department of Agriculture, will shortly go overseas to study vegetable production and processing methods in U.S.A., Canada and the United Kingdom. Mr. Orman, who has already done much to raise the standard of vegetable growing and marketing in New South Wales, will be away about eight months.

Mr. J. Fisher-Pollard has resigned from the Horticultural Division of the N.S.W. Department of Agriculture to take up a position as Field Officer with Potash (Australasia) Pty. Ltd. in Sydney.

Queensland

Dr. R. G. Coleman who recently gained the degree of Doctor of Philosophy in the University of London has been appointed to work on plant nutrition at the Plant and Soils Laboratory, C.S.I.R.O., Brisbane.

Mr. O. T. Denmead has been awarded the Robert Philp and the Edwin Munro Scholarships and will undertake post-graduate studies in Soil Science at the University of Queensland.

Dr. E. M. Hutton and *Dr. D. O. Norris* have recently transferred from Canberra to the Plant and Soils Laboratory, C.S.I.R.O., Brisbane.

Mr. S. V. Patel, of India, and *Mr. S. K. A. Weerawickrema*, of Ceylon, have completed their post-graduate studies at the University of Queensland and returned to their home countries.

Mr. F. A. Perkins, Chief Lecturer in Entomology, University of Queensland, will be Dean of the Faculty of Agriculture during 1954.

Mr. J. G. Young, a Cattle Husbandry Officer of the Department of Agriculture and Stock, has been transferred from Emerald to Brisbane.

The following changes have been effected in the Queensland Department of Agriculture and Stock: *Mr. D. O. Atherton*, from Director of Agriculture to Director of Tropical Agriculture, with headquarters at South Johnstone; *Mr. W. J. S. Sloan*, from Assistant Director of Agriculture to Director of Agriculture; *Dr. L. G. Miles*, from Senior Plant Breeder to Assistant Director of Agriculture; *Mr. A. R. Brimblecombe* and *Mr. A. W. S. May*, Entomologists, to be Senior Entomologists at Brisbane and Toowoomba respectively; *Mr. T. McKnight*, Plant Pathologist, to be Senior Plant Pathologist, with headquarters at Toowoomba; and *Mr. D. Rosser*, Plant Breeder, to be Senior Plant Breeder.

Several student members who recently completed the course for the Degree of Bachelor of Agricultural Science at the University of Queensland have received appointments with the Department of Agriculture and Stock. They are *Mr. E. Jones* (Plant Breeding), *Mr. D. S. Teakle* (Plant Pathology) and *Mr. G. W. Saunders* (Entomology). Another recent graduate, *Mr. N. McCowan* has been appointed to the Technical Field Staff of the Colonial Sugar Refining Co. Ltd. in Fiji.

South Australia

Mr. J. R. Botham has left the Shell Co. Adelaide and joined the Horticultural Branch of the S.A. Department of Agriculture.

Dr. T. Browning, entomologist at the Waite Agricultural Research Institute, has returned from studies at the Birmingham University. He came via the U.S.A. on a Carnegie grant.

Dr. A. R. Callaghan has returned from Rome where he represented the Commonwealth at the seventh annual conference of F.A.O.

Mr. G. R. Edwards, Horticultural Research Officer in the Department of Agriculture has returned to Adelaide after 18 months in the United States where he studied vegetable production.

Mr. J. R. Goode has accepted a 12 months appointment with F.A.O. in British Guiana, and has been granted leave by B.H.P., Whyalla. He will first travel to Rome.

Mr. W. H. Litchfield of the C.S.I.R.O. Soils Division based at the Waite Institute has been transferred to Queensland.

Mr. J. V. Mertin has resigned from the Division of Plant Quarantine, Canberra, to take a position with Wm. Haughton Ltd. Adelaide.

Dr. C. S. Piper, Chief Chemist at the Waite Agricultural Research Institute, has returned to duty after visiting the United Kingdom, Europe and the United States.

Mr. B. A. Roark resigned his appointment at the Waite Institute at the end of last year. He has journeyed to Perth prior to leaving Australia for the United States.

Mr. P. G. Schinckel has resigned the post of Senior Lecturer in Animal Husbandry at Roseworthy College to become Principal Research Officer at the C.S.I.R.O.'s new sheep biology laboratories at Prospect, N.S.W.

Victoria

Mr. T. C. Bell, who until the end of 1953 was with the Agricultural Research Liaison Section of C.S.I.R.O., is now with Personnel Administration (Aust.) Pty. Ltd., a firm of Management Consultants.

Dr. F. J. R. Hird, Senior Lecturer in Biochemistry, has been awarded Fulbright and Smith-Mundt grants to enable him to work in America for a period of six months, chiefly at Yale University Medical School.

Mr. N. C. Killeen has resigned from his position as Manager, Rutherglen Research Station, and is now farming. *Mr. J. S. Bath* is now Acting Manager, Rutherglen.

Mr. H. G. Turner has been transferred from C.S.I.R.O., Animal Health and Production, Parkville, to that Division's Field Station at Belmont in Queensland where he will undertake research on beef cattle.

Mr. C. S. Webb has resigned from his position with the "Weekly Times" to be Information Liaison Officer, Department of Agriculture, a post created as a result of the Commonwealth Government's grant to increase primary production.

Western Australia

Mr. S. DeBeaux has resigned from the Department of Agriculture and taken up an appointment on the staff of the Supervisor of Fresh Fruit Exports of the Department of Commerce and Agriculture.

Dr. K. W. Finlay has been awarded a Nuffield Dominion Travelling Scholarship. He departs for England on March 7, 1954, and will work at Rothamstead.

Mr. L. T. Jones, Senior Plant Research Officer of the Department of Agriculture, attended an inter-departmental conference on the use of lime in agriculture held at Melbourne. Subsequent to the conference he visited vine growing areas in Victoria and South Australia.

Mr. F. Ryan, Agrostologist of the Department of Agriculture, attended the meeting of the Dairy Officers of the Departments of Agriculture and representatives of the Department of Commerce and Agriculture held at Brisbane.

Mr. L. Shier, the Assistant Superintendent of Wheat Farming of the Department of Agriculture, has returned from New Zealand. There he spent 6 weeks making a study of Agricultural Extension Services and visiting Agricultural Institutions and Research Stations.

Mr. I. Thomas, formerly Superintendent of Wheat Farming, has been appointed Deputy Director of Agriculture.

Messrs. A. M. Stewart and *J. Silsbury* of the W.A. Institute of Agriculture and *Mr. M. Wallace* of C.S.I.R.O. attended the A.N.Z.A.A.S. conference at Canberra.

NEWS ITEMS

Back Numbers Wanted — Vol. 17, No. 1

Copies of Vol. 17, No. 1 (March, 1951) of the Journal are urgently required by the management to complete essential Institute records; this issue is also in demand by subscribers and libraries wishing to complete their sets.

Please send your copy to:—The Hon. Business Manager, J. A.I.A.S., C/- Librarian, Department of Agriculture, Treasury Place, Melbourne, C.2. and show sender's name and address clearly on the wrapper.

For each copy of this issue received the management will remit 5/- unless the sender specifically desires to have the copy accepted as a donation.

Sir Benjamin Fuller Research Scholarship

The Ben Fuller Trust has just announced another research scholarship tenable overseas. It is open to graduates in Agriculture or Veterinary Science who will be free to nominate the type of work they wish to do and the research institution at which they wish to work abroad. The Trustees have made this scholarship sufficiently attractive financially to interest even senior people. It is tenable for two years and its value is approximately £1,300 per year. Unfortunately, because the funds available to the Trust are small, it is probable that this will be the last scholarship it will be able to award.

A.N.Z.A.A.S. — Agriculture and Forestry

The Australia and New Zealand Association for the Advancement of Science held its 30th Meeting in Canberra during the period 13-20th January. The programme of Section K (Agriculture and Forestry) was well received, the average attendance being in excess of 150.

The main symposium, which was related to the world's food and agricultural problems, provided an opportunity for a very instructive address by Dr. Wahlen, the Director of the Agricultural Division of F.A.O., who was a special guest of the meeting. The policy, scientific, nutritional and practical aspects were covered by various speakers with particular reference to Australia's immediate and longer term problems. The contributors, in addition to Dr. Wahlen, were Mr. J. G. Crawford, Dr. I. Cluniès-Ross, Dr. F. W. Clements, Mr. J. A. Taylor, Dr. W. A. T. Summerville, Dr. A. R. Callaghan and Mr. W. A. Gunn. The papers presented at this symposium will be published in the June issue of this Journal.

The papers presented throughout the week covered most major fields of agricultural science and included soil and plant symposia, and symbiotic nitrogen fixation and nutrition. A paper from Professor J. R. A. McMillan was delivered on the subject of "The Role of the Universities in Agricultural Research". Also the Presidential address by Associate Professor G. W. Leeper on "The Place of the Critic in Science" was well received by a large and enthusiastic audience.

Dr. O. H. Frankel

Dr. O. H. Frankel, F.R.S., Chief, Division of Plant Industry, C.S.I.R.O., returned from a brief overseas trip early in November. He visited the headquarters of the United Nations Food and Agriculture Organisation in Rome and took part as a representative of Australia in the Ninth International Genetics Congress at Bellagio, Italy, where he read a paper on: "Invasion and evolution of plants in Australia and New Zealand."

Dr. Frankel spent six weeks in the United Kingdom including a visit to Holland, mainly with a view to exploring possibilities of engaging research staff in various fields of interest to the Division of Plant Industry and in particular in genetics and biochemistry. He returned to Australia by way of the United States where he paid brief visits to Columbia University, New York; the California Institute of Technology, Pasadena; and the Universities of California, Los Angeles, Berkeley and Davis. Dr. Frankel spent most of his time with workers in genetics and physiology and in particular paid a visit to the phytotron at the California Institute of Technology. He was impressed with the potentialities the establishment of exhaustive controlled environment facilities holds for many fields of plant research in Australia.

Wheat Research Grant

The New South Wales Flour Mill Owners' Association has given the Sydney University the sum of £8,350 for wheat research. Of this £5,050 is allocated for the purchase of the 16-acre property at Castle Hill near Sydney which the University has been renting. Dr. T. A. Watson of the Faculty of Agriculture has been working there for the last 3-4 years, the property being used for early stage breeding for stem rust resistance in wheat and oats. Under the terms of the grant, improvement of wheat quality is to be one of the principal aims of the intensified breeding investigations. It will be recalled that the higher quality, rust-resistant variety, Gabo, which is now one of our most important wheats, is a product of Professor Waterhouse's team which has done so much for the wheat industry.

The Waterhouse tradition will be ably maintained under the leadership of Dr. Watson. Wheat breeding research at the Sydney University will be greatly assisted by the millers' very practical help.

Plant Collection Expedition

Mr. C. A. Neal-Smith, Research Officer, of the Plant Introduction Section, C.S.I.R.O., Canberra, left Australia on 23rd February for a period of nine months to carry out, under the joint auspices of the United Nations Food and Agriculture Organisation and C.S.I.R.O., a pasture and forage plant collecting project in the Mediterranean area. His headquarters will be in Rome, but the major portion of the time will be spent in the North African countries of French Morocco, Algeria and Libya. In addition, it is anticipated that visits of short duration will be paid to Cyprus, Israël and Turkey. In the latter country he will attend the third meeting of the F.A.O. Working Party on Mediterranean Pasture and Fodder Development.

Agricultural Extension Scholarships

The Victorian Department of Agriculture is awarding scholarships this year to students undertaking the Agricultural Science course at Melbourne University. This has been made possible from funds provided under the Commonwealth Extension Services Grant. The scholarships will be awarded to a number of matriculated students undertaking the course and to students already in the second, third and fourth years of their courses. In addition to payment of University fees the scholarships will provide a living allowance which is up to £350 per annum for students living away from home. It is hoped that the scholarship scheme will provide the incentive for young men to take up a career in agricultural extension work. On completion of their course the scholarship holders will be appointed to permanent positions in the Department of Agriculture, to undertake district agricultural extension work after undergoing a special period of training. The commencing salary on present rates, would be £962 per annum with a range to £1196.

Inglewood Tobacco Experiment Station

The Queensland Department of Agriculture and Stock has acquired a farm for development as a Tobacco Experiment Station. The property is located about 10 miles from Inglewood in southern Queensland. There are approximately 70 acres of land, much of which is typical of soils on which tobacco is grown in the district. A soil survey and a land use map of the area have been completed. Experimental work has begun with the establishment of a crop rotation trial. Observation plots with fertilizers and trace elements will also be planted, as well as seed increase plots of commercial tobacco varieties for sale to growers in Queensland. Furrow irrigation will be used throughout.

Dr. J. H. Beaumont

Dr. J. H. Beaumont, Director of the Hawaii Experiment Station, University of Hawaii, arrived in Australia in November. He is here under a Fulbright award to investigate the field occurrence of *Macadamia* (Queensland Nut), and to study the horticultural varieties of the tree, and the possibility of hybridization between the species formerly known as *Macadamia ternifolia* and *M. integrifolia*. Dr. Beaumont has made the University of Queensland his headquarters, and his field time will be spent in southern Queensland and northern New South Wales in the company of officers of the C.S.I.R.O. and the Departments of Agriculture of the two States.

Scouts' Expedition to Tasmania

The Boy Scouts' Expedition to the West Coast of Tasmania made in December and January was completed according to plan. The co-operation between the boys of the various scientific patrols and the non-scout scientific leaders was excellent and the expedition proved a very good means of interesting boys in the various sciences. It is likely that there will be several recruits to one or other of the scientific studies as a result of this experience.

Australian Genetics Society

The second meeting of the Australian Genetics Society was held in Canberra on 11th and 12th January. Thirty-five members attended and seventeen papers were presented.

A review of the various types of cytological polymorphism in grasshopper populations and the evolutionary significance of these chromosomal changes was given by Dr. M. J. D. White. This was followed by a series of papers relevant to animal breeding which dealt with methods of assessing environmental variability; the importance of recessive lethal factors in artificial insemination programmes; the genetic implications of the stud Merino flocks on the sheep industry; investigations on fleece weight and the effect of flock size in breeding programmes.

Other papers were given on the genetics of *Nurospora crassa*, the mutagenic effects of xanthene dyes and formalin, developmental genetics in the mouse, the inheritance of supernumary chromosomes in maize, cytological abnormalities in endosperm and pollen mother cells of plant hybrids and chromosomal morphology of Australian species of *Drosophila*.

The meeting ended with a symposium on the teaching of genetics. Dr. O. H. Frankel and Dr. F. H. W. Morley outlined the requirements for geneticists in the plant and animal fields of agriculture, while Prof. D. G. Catcheside and Dr. J. M. Rendel described various aspects of the training of geneticists.

A regrettable feature of the meeting was the absence of plant breeders. Further meetings are being arranged by the Secretary, Mr. P. G. Martin, Department of Genetics, Waite Agricultural Research Institute, Adelaide, and it is to be hoped that at future meetings representatives of all sections of genetics in Australia will be present.

LETTERS TO THE EDITOR

Sir,

Sulphur Deficiency in Australian Soils.

The earlier article on this subject by A. J. Anderson in this Journal in 1952, and the subsequent letter by C. W. Winders, also in this Journal in 1952, do not mention the earlier work with sulphur in Victoria.

H. A. Mullet and P. Rankin Scott in 1923 referred to the experimental use of sulphur at Werribee, Victoria, in 1920-22. Their paper in the Journal of the Victorian Department of Agriculture, on the use of gypsum for the improvement of the mechanical condition of soils and subsoils discusses gypsum as a source of a plant food, sulphur. Reference is made to the application of sulphur to lucerne at Werribee. The following experimental data and their comment indicate the early interest in sulphur as a plant nutrient.

Experiments with lucerne at Werribee, 1920-1922 inclusive.

Treatment	Average yield, cwt.
No manure	116.8
Sulphur 1 cwt.	129.4
Super 1 cwt.	135.3
Super 2 cwt.	143.6
Super 3 cwt.	146.3
Super 4 cwt.	151.6
Super 2 cwt. + gypsum 1½ tons	158.2
Super 2 cwt. + lime 10 cwt.	138.9
Super 2 cwt. + lime 20 cwt.	142.9

"Sulphur has recently been proved of more importance as a plant food than was formerly supposed. Applications of 2 cwt. of sulphur spread over 2 years have resulted in an increase of 11 per cent in the yield of lucerne at Werribee. Curiously enough this increase is very much of the same order as increase in lucerne attributable to gypsum there. Possibly then, this is the explanation for the increase due to gypsum there."

G. BLACKBURN.

Division of Soils,
C.S.I.R.O.,
ADELAIDE.
10th December, 1953.

Sir,

Referring to the article on "The Brigalow Country," published by Skerman in the September issue, we would like to contribute some notes based on experience over 20 years on a property at Theodore in the Dawson Valley.

Two heavy crawler tractors with a cable between them are used for pulling over the dense scrub, but a single bulldozer is more effective against large suckers, which are bent over by the cable treatment. The material is then left to dry, and is burnt off during the first hot, dry spring period. If a good body of grass is present amongst the timber, so much the better.

Following clearing, the land is ploughed, and the "Majestic" plough as mentioned by Skerman effectively handles this job, and will successfully handle suckers up to four feet high. Preparation of the land for wheat is then proceeded with, and the crop is planted according to planting rains about June.

After this first harvest, the object is to obtain a sorghum crop on that same area, and the stubble is disced in, or if bulky, may be burnt to allow for planting of the grain sorghum about January. This early double cropping permits the suppression of brigalow suckers, and the two crops for the one preparation normally gives sufficient income for more developmental work.

Following this first sorghum crop, Rhodes grass is sown down for three years. The area is then ploughed again with a heavy plough to destroy any further suckers, and the rotation of wheat, sorghum, three years Rhodes grass continued.

In a pioneering programme, this system has proved successful, but we realise this rotation is not ideal—the inclusion of some legume would be advantageous. Until such time as a suitable dominant legume, to be included with the grass, can be provided for these areas, the inclusion in the rotation of either a crop of cotton, or Poona peas, or some similar crop which yields an easily harvested and marketable product, is being considered.

C. J. LETCHFORD.
J. M. LETCHFORD.

"Cosmos", Theodore, Queensland.
16th December, 1953.

BOOK REVIEWS

MANUAL OF BACTERIAL PLANT PATHOGENS

By CHARLOTTE ELLIOTT

(Chronica Botanica Co., Waltham, Mass., U.S.A.; N. H. Seward, Melbourne, 1952, 2nd. Edition, revised, 186 pp., 69/3).

There have been important developments in the field of bacterial plant pathology since the publication in 1930 of the first edition of this work. Using the framework of her original publication, Dr. Elliott has incorporated in this second edition a comprehensive and detailed picture of the present knowledge.

The book is divided into two parts. The main section deals with the recognized plant pathogens. Part II is entitled "Bacterial species reported in the literature from plants, but not recognized as valid plant pathogens."

Dr. Elliott's system of classification closely follows the pattern set out by Bergey *et al.*

(1948). She is thus in agreement with Dowson (1948) in his use of the genera *Corynebacterium* (Jensen), *Pseudomonas* (Migula *emend.* Dowson) and *Xanthomonas* (Dowson) but has rejected his definition of the genus *Bacterium*. As in Bergey, this latter term has been used instead in the manner of Breed and Conn (1936) to include those species of non-sporing rods whose relationships to other bacteria are not clearly defined. The motile, gram negative, peritrichous organisms defined under *Bacterium* by Dowson are grouped (again as in Bergey) into *Agrobacterium* (Conn 1942) and *Erwinia* (Winslow *et al.* 1920). A short description of each of the genera used in Part I is given in the preface, but no definitions have been given for the genera of *Bacillus*, *Micrococcus* and *Proteus* as employed in Part II.

The species are described in alphabetical order within each genus and for each organism details are given of history of nomenclature, morphological and biochemical properties, disease manifestations, host range, geographical distribution and control methods. The extensive yet selective literature references supplied at the end of each description date from 1929. The reader is referred to the first edition for literature previous to this date. Full and carefully prepared indices for both hosts and parasites are supplied at the end of the book.

With the science of bacterial plant pathology still in its active developmental stage, it would have been impossible to have compiled a work of this massive nature without provoking some differences of opinion. For instance, there will be many, like the reviewer, who will query the allocation of species status to *Ps. syringae* type pathogens such as *Ps. Barkeri* and *Ps. nectarophilum*. Others will challenge the relegation of particular organisms to Part II of the book. However, Dr. Elliott's established reputation as one of the foremost workers in the field entitles her views on these and other contentious items to the respect, if not the accord, of all.

Viewed as a whole, this timely and authoritative work will be greeted with enthusiasm by plant pathologists and bacteriologists and will serve as a constant source of reference for many years to come.

H. FREEMAN.

GUIDE TO THE CHEMICALS USED IN CROP PROTECTION

By H. MARTIN and J. R. W. MILES

(*Dominion of Canada, Department of Agriculture, Science Service*, 1952, 236 *pp., processed*).

Agricultural biologists, chemists, and extension workers who have endeavoured, at the expense of much time and labour, to keep pace with the rapid recent developments in the field of crop protection by chemical means will welcome the publication of this handbook of data on the major chemicals used in crop protection at the present time. The Guide would have fulfilled a long-felt need even if its sole purpose had been to define the chemical identity of materials which have been referred to in the literature by abbreviated and ambiguous chemical names, trade names, and even manufacturers' code numbers. In addition to establishing synonymy, however, it contains a great deal of useful and accurate technical information on the nature, properties and uses of the materials, condensed into a readily available form.

The Guide comprehensively covers the present range of biologically-active materials of proven value in the control of insects, mites, fungi, weeds, rodents, etc., and includes data on some biologically-inert materials useful in the formulation of the former. The materials dealt with are not grouped into these categories, however, but are treated in alphabetical order, the nomenclature being either the full chemical name, a shortened version of this, or the approved or proposed common name. In all possible cases the full chemical name and the structural formula have been given. Alternative names, including trade names used in scientific literature, are included in the text and index.

For each material the data are presented in concise note form under the headings: history, manufacture, physical properties, chemical properties or chemistry, biological properties (including mammalian toxicity), formulation, and analysis (macro- and micro-). The citing of literature references in the text is a commendable procedure which makes the information on each material completely self-contained.

The majority of the 177 materials covered by this publication are synthetic chemicals developed during the last 12 years. Most of these have already been widely used in modern agriculture. The remainder are newer materials, still in the experimental stage, which the authors consider will eventually find practical use.

Fully aware of the rapid progress which is being made in the field of crop protection chemicals, and the desirability of keeping a publication of this nature up-to-date, the authors have wisely chosen to publish the Guide in a loose-leaf form to allow for the insertion of revised and supplementary sheets. If their intention to revise and add to the present publication from time to time is fulfilled, their Guide will undoubtedly prove to be as valuable and convenient a source of basic information on crop protection chemicals in the future as it is at the present time.

R. W. KERR.

APPOINTMENTS VACANT

Commonwealth Scientific and Industrial Research Organization

DIVISION OF PLANT INDUSTRY

Applications are invited for appointment to a position of **TECHNICAL OFFICER.**

Location: Headquarters of the Division of Plant Industry, Black Mountain.

Duties: To carry out ecological studies of sown species in areas of moderate rainfall. The programme will include glass-house experiments.

Qualifications: Degree in agricultural science, preferably with some experience in field experimentation or equivalent qualifications.

Salary: Technical Officer, £620-£908 nominal.

The appointment will be conditional on a satisfactory medical examination and the successful applicant may be asked to serve for an initial probationary period of up to twelve months before being confirmed in his appointment as an officer of the Organization. If so confirmed he will be eligible to contribute to, and receive benefits from either the Commonwealth Superannuation Fund or the Commonwealth Provident Fund.

Applications referring to appointment stating full name, place, date and year of birth, marital state, nationality, present employment, particulars of qualifications and experience, and of war service, if any, accompanied by copies of not more than four testimonials, should reach the Chief, Division of Plant Industry, Box 109, P.O., Canberra. Applications will be received until 23rd April, 1954.

BIOLOGISTS

Imperial Chemical Industries of Australia and New Zealand Ltd.

Applications are invited from University graduates specialising in Plant Physiology, Entomology, Plant Pathology or Veterinary Science and interested in field, laboratory or library work at the Company's new Biological Laboratory near Melbourne. Salary according to age and experience.

Address applications, stating age, qualifications and experience to Personnel Department, I.C.I.A.N.Z. Ltd., Box 1911, Melbourne.

AGRICULTURAL SCIENCE

An Agricultural Science or similar graduate is required by a leading Mercantile company with extensive stock and station interests in Western Australia to advise its clientele and assist in promoting sales of plant and animal pesticides. Salary £1,050 per annum or higher according to qualifications and experience.

Reasonable assistance in financing the purchase of a home will be considered if necessary.

Written applications enclosing copies only of references should be addressed to:

Staff Superintendent,
Westralian Farmers Co-operative Ltd.,
569 Wellington Street, PERTH,
WESTERN AUSTRALIA.

Preliminary interviews will be arranged in Melbourne.

Technical Assistant in Seed Analysis and Seed Testing; and relating to Seed borne disease control; and generally to the application of developments in Agricultural Science.

A male or female graduate in Agricultural Science is required by:

ARTHUR YATES & CO. PTY. LTD.

The largest Seed Growers and Seed Merchants in Australia.

Salary according to qualifications and experience but based on approximately £800 per annum for men, and £640 for women.

Applicants are requested to give full particulars of previous experience, and of any special interest in relation to any of the above matters; and other information likely to assist the Company in selecting a suitable person.

All applications must be in writing to:

"Science Graduate,"
C/o Arthur Yates & Co. Pty. Ltd.,
Box 2707, G.P.O.,
SYDNEY.

PUBLIC SERVICE OF PAPUA AND NEW GUINEA — VACANCIES

Applications are invited from persons desirous of appointment to the undermentioned positions in the Papua and New Guinea Public Service.

Department of Agriculture, Stock and Fisheries.

Publications Officer: £1,208-£1,304 p.a.

Qualifications: Degree or diploma in Agricultural Science with sound literary ability. Experience in and capacity to prepare and edit technical publications in agricultural fields.

Duties: Collection, special editing and preparation of matter for publications, i.e., Agricultural Gazette, bulletins, pamphlets, etc. Ordering and maintenance of stocks of publications.

Veterinary Officer, Grade I: £1,208-£1,304 p.a.

Qualifications: University degree in Veterinary Science.

Duties: Undertake duties in fields of disease control, animal husbandry and quarantine. Supervise work of stock inspectors and other lay field staff.

Agricultural Officer, Grade I: £968-£1,256 p.a. (4 positions).

Qualifications: University degree in Agriculture.

Duties: General agricultural extension duties, including supervision of district projects, maintenance of district or sub-district agricultural stations.

Soil Survey Officer, Grade I: £968-£1,256 p.a.

Qualifications: University degree in Agriculture or equivalent degree. Post-graduate experience in soil survey techniques an advantage.

Duties: Participation in soil and resources surveys and compilation of appropriate data, reports and maps; preparation, maintenance and ordering of field equipment.

Agronomist, Grade I: £968-£1,256 p.a. (3 positions).

Qualifications: University degree in Agriculture. Post-graduate experience in Agronomy an advantage.

Duties: Under direction design, supervise, record and interpret experiments covering cultivation, fertilisers, crop testing and variety trials with a wide range of crops.

Entomologist, Grade I: £968-£1,256 p.a. (2 positions).

Qualifications: University degree in Agriculture or equivalent degree with Entomology as a major subject.

Duties: Field investigations and bionomic studies of pests. Experiments in pest control and other investigations under the direction of the Senior Entomologist.

Assistant Agricultural Officer: £581-£1,112 p.a. (for minimum salaries payable to appointees under 24 years see heading "salary") (8 positions).

Qualifications: Diploma of approved Agricultural College.

Duties: General agricultural extension duties under supervision, including supervision of district projects and technical duties on behalf of specialist division as required.

Assistant Animal Husbandry Officer: £581-£1,112 p.a. (for minimum salaries payable to appointees under 24 years see heading "salary").

Qualifications: Diploma in Agriculture or Animal Husbandry from recognised Agricultural College. Knowledge of principles of animal husbandry, animal nutrition and pasture improvement. Experience in stock management.

Duties: Implement and keep records of pasture trials, animal nutrition trials and experimental work under direction of professional officers. Care of livestock, maintenance of pastures and general station duties.

General Information.

Conditions of Service: As prescribed in the Public Service Ordinance 1949-50 of the Territory of Papua and New Guinea and regulations made thereunder. The conditions are similar to but not identical with those of the Commonwealth Public Service. Provision exists under the Ordinance for officers of Commonwealth and State Services to retain certain rights on appointment to the territorial service.

Salary: Rates quoted are actual and include the cost of living adjustment and territorial allowance. Married officers receive an additional £100 p.a. A commencing salary will be paid according to qualifications and experience.

Appointees as Assistant Agricultural Officer and Assistant Animal Husbandry Officer, who are under the age of twenty-four years, will be paid a minimum salary in accordance with the following scale:—

18 years	£581	21 years	£872
19 years	£674	22 years	£896
20 years	£766	23 years	£920

Eligibility: Male British subjects, 18 to 45 years.

Qualifications: Australian qualifications or their equivalents required.

Terms of Appointment: On probation with a view to permanency.

Location: Any part of the Territory.

Superannuation: An officer is required to contribute to the Superannuation Fund in accordance with the Superannuation (Papua and New Guinea) Ordinance 1951-52.

Accommodation: Single accommodation only available in the first instance.

Leave: Three months, after twenty-one months in the Territory.

Taxation: Income derived by residents of the Territory from sources within the Territory is not at present taxable under Commonwealth legislation.

Further Information: Enquiries should be directed to the Secretary, Department of Territories, Canberra.

Applications: Applications must be lodged on the prescribed form, copies of which are available from—

Country Post Offices (official offices only).
District Employment Offices.
Commonwealth Public Service Inspectors.
The Secretary, Department of Territories, Canberra.

Applications close with the Secretary, Department of Territories, Canberra, on Saturday, 17th April, 1954.

APPOINTMENTS VACANT

The McCaughey Memorial Institute is seeking a Director of Research.

The Institute has been established, as a memorial to the late S. M. McCaughey and D. L. MacPherson, to undertake research and extension work in animal production in the Riverina.

The Director will be required to conduct, organize and supervise the research and extension activities of the Institute, which will be concerned particularly with sheep, cattle and pigs under dry farming conditions and irrigation.

The Institute is being established on a property of approximately 24,000 acres which was a portion of the original "Coree" Station in the Jerilderie District. Half the area is typical merino and cattle country, and the remainder suitable for intensive development under irrigation.

It is intended that the original homestead shall serve as headquarters for administration and research and student quarters.

The appointment will be initially for a period of seven years at a salary commencing at £1,500 per annum, with annual increments and provision for superannuation. Suitable quarters at the homestead and keep will be provided.

Applications will be received by the Secretary of the McCaughey Institute, 89 Phillip Street, Sydney, until 28th May, 1954.

LECTURER IN AGRONOMY.

School of Wool Technology, N.S.W. University of Technology.

Salary £1,102 range £1,402 p.a. Commencing salary in accordance with qualifications and experience.

The successful applicant will be responsible for courses in Agronomy, Pastoral Agronomy and either Farm Management or Farm Livestock to under-graduate and post-graduate students. Preference to graduates in Agricultural Science having experience in research and/or extension work in this field in the pastoral industry. The appointee will be expected to take an active part in the School's research programme, which is especially concerned with the application of research results in practice.

Further information can be obtained from the Professor of Wool Technology, School of Wool Technology, Forbes Street, Darlinghurst, N.S.W., or from the Registrar, N.S.W. University of Technology, Broadway, N.S.W.

Apply Registrar, N.S.W. University of Technology, Broadway, N.S.W., marking envelope "Employment", by 3rd May, 1954.

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